GALL MIDGES OF ECONOMIC IMPORTANCE

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GALL MIDGES OF ORNAMENTAL PLANTS AND SHRUBS

With a Foreword by
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Royal Horticultural Society

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Vol. I. Gall Midges of Root and Vegetable Crops

Vol. II. Gall Midges of Fodder Crops

Vol. III. Gall Midges of Fruit

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Vol. V. Gall Midges of Trees

Vol. VI. Gall Midges of Miscellaneous Crops

Vol. VII. Gall Midges of Cereals

Vol. VIII. Gall Midges—Miscellaneous (zoophagous, fungivorous, and those that attack weeds)

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Foreword

A group of insects associated with injury to ornamental plants and shrubs, and the least familiar to the floriculturist, is that known as the Gall Midges. In recent years, however, the horticultural community has become aware of the potential dangers arising from outbreaks by many flower-infesting species, more especially the Chrysanthemum and Violet Gall Midges.

For many years, five names have been recognized as world authorities on this group, namely, Barnes in England and Felt in the United States of America, Kieffer in Lorraine, Rübsaamen in Germany and Tavares in Portugal. Entomologists in all countries invariably consult the publications of these authorities whenever information concerning the taxonomy and biology of gall midges is required. The only survivor of the five is the author of this invaluable volume on *Gall Midges of Ornamental Plants and Shrubs*; he directed attention to this group of insects in a paper published in the *Journal of the South-Eastern Agricultural College, Wye*, in 1927, and entitled: "Material for a Monograph of the British Cecidomyidae". This volume of his work on gall midges of economic importance considerably extends our knowledge of the global species concerned with injury to flowers and shrubs.

The problem of curtailing outbreaks of gall midges in nurseries and gardens is far different from that which confronts the agriculturist, market-gardener and fruit-grower in dealing with infestations of cereal-, pasture-, vegetable- and fruit-infesting species. Measures designed to control infestations in the field are inadequate against those that infest flower crops, grown under totally different conditions, and alternative measures are necessary. It is of interest to growers to learn that the warm-water treatment, now a familiar technique

against certain eelworm pests of ornamentals (in particular, Narcissus bulbs and Chrysanthemum stools), may be adopted for the control of such pests as the Box Midge in nursery stands.

The author has long been attracted to the long-range forecasting of insect outbreaks, especially in relation to certain pests of cereals, and it is hoped that the data accumulated by Dr. Barnes will be extended to forecasting outbreaks of other gall midges, including those of ornamentals.

Among the more important flower-infesting species in this country are the Arabis, Box, Chrysanthemum and Violet Gall Midges, while the importance of Hawthorn as an alternate host for certain fruit-infesting species should be viewed with sane but insistent concern by those whose interest lies in the cultivation of hardy fruits. The presence of *Clinodiplosis* larvae among samples of flower seeds frequently arouses the attention of seedsmen, who are unaware of the nature of these harmless maggots and who seek advice as to the methods of ridding their stocks of them.

While many applied entomologists are and have been interested in taxonomy, there are few who are gifted with a combination of the highly critical mind of the systematist with the perspicacity of the applied worker. In this and other volumes of the work one observes the almost unique combination of both, and notes the meticulous care that has been taken in the preparation of this monograph, which should prove a source of inspiration to other biologists who will wish to emulate the work of the author.

Our present knowledge of gall midges is largely due to the investigations carried out by the aforementioned authorities. The further research that will inevitably be stimulated by this volume will indicate the host range of many species and provide more effective measures for controlling outbreaks of gall midges under field, nursery and garden conditions.

G. FOX WILSON.

R.H.S. LABORATORIES,
WISLEY,
SURREY.
November, 1945.

Preface

In the Preface to Vol. I of this work of reference (32), mention is made of the need of such a book, its basis on the literature and on the personal investigations of the author, his methods and the manner in which it is proposed to deal with the gall midges of economic importance throughout the world. Vol. I then dealt with the gall midges of root and vegetable crops.

In the Preface to Vol. II (33) attention was drawn to the paucity of exact biological studies, particularly in regard to host plant range, and to the facile manner in which faunal lists have sometimes been compiled in the past. Vol. II then dealt with the gall midges of fodder crops.

In the Preface to Vol. III (34) attention was focused on two matters of general interest—the species problem and the need for phenological observations to aid correct timing in control measures. Vol. III then dealt with the gall midges of fruit, but not of hops since they are being reserved for inclusion in Vol. VI.

In this Vol. IV the gall midges of ornamental plants and shrubs will be considered in the same manner, most emphasis being laid on their biology and control. The volume starts with an alphabetical list of the ornamental plants and shrubs to be dealt with, and indicates the midges that attack them, the part of the plant attacked and the pages on which the information concerning the species is to be found. Then the gall midges are considered under the plants or shrubs they attack, arranged in alphabetical order.

In such a volume as this dealing with the gall midges of ornamentals of the world it has been especially difficult to decide what plants to include and what to omit. A plant considered as worthy of cultivation for its beauty in one country

may be rejected as an unwanted weed in another. The final selection has rested with the author, who is responsible for any omissions—but he would consider it a favour to have criticism of his selection. Some plants, the midges of which have not been dealt with in this volume, have been omitted because they receive attention in other volumes, the plants in question being considered of less importance as ornamentals than for other purposes. For example, Rosemary appears in Vol. VI in the Herb section, which includes aromatic, culinary and medicinal herbs.

The gall midges considered fall as usual into three categories: those that are already known to be pests; those that, while occurring on cultivated ornamental plants and shrubs, have not yet been recorded as pests; and those that, while not yet reported from cultivated plants, are known to live on closely related plants and may in the future turn their attention to the cultivated species. Those that are already known as pests and about which there is more information available are considered under such side headings as diagnostic character, damage, description, distribution, life history, food plants, natural enemies and control. In such instances a list of the most important references, the original description and important papers on the biology and control, are listed at the end of the section dealing with the species under consideration. The remaining gall midges are dealt with in a manner designed to emphasize what information is available concerning their life history, food plants and natural enemies. The text is fully annotated throughout, thus providing a means of pursuing any statement further. The same general policy has been adopted throughout the whole work.

This was originally intended to be contained in one volume. It soon became apparent, however, that such a work would be an unwieldy tome. Consequently, the decision was taken to split it into eight self-contained volumes, which it is hoped will make their appeal to different groups of agriculturists and horticulturists. This splitting has resulted in occasional repetitions. Thus, it would have been wrong not to have dealt with the Red Bud Borer, which attacks grafts of various fruit trees,

in Vol. III. It would have been equally inadmissible not to have included it in the present volume, since the midge is even better known from its attacks on rose-tree grafts. This being so, it was decided to include it in both volumes. In a few other instances, in order to avoid actual repetition, resort has been made to cross-referencing from one volume to another.

This volume ends, in the same manner as the previous ones, with a list of references used, an index to the generic, specific and popular names of the gall midges mentioned, a plant index and a general index.

It is thought appropriate to mention here the genus *Clinodiplosis* of gall midges because the yellow-orange larvae belonging to this genus are so often found among the flowers and seeds of ornamental plants. Together with these larvae, there are frequently red gall midge larvae, but usually in much smaller numbers. These latter larvae may be easily distinguished by their difference in colour and the fact that they do not possess the breastbone or anchor-process, which is as a rule such a feature of gall midge larvae. These larvae belong to the genus *Lestodiplosis* and are predaceous, being therefore to some extent beneficial since they usually feed on injurious insect larvae in the flower heads, or else on the mites that are so often found among stored seed. They will receive detailed attention in Vol. VIII.

The exact nature of the food of the *Clinodiplosis* larvae is still uncertain (31). Sometimes they are undoubtedly inquilines living in company with injurious gall midges or other insects. For example, *Clinodiplosis pisicola* Barnes, which frequently is to be found in pea pods infested with the Pea Midge (*Contarinia pisi* Winnertz) (32, and p. 110 of this volume). *Clinodiplosis* larvae have also been found in Gorse pods in which the Gorse Weevil, *Apion ulicis*, was present, and in Hollyhock seed clusters in which the larvae of the Hollyhock Moth, *Platyedra malvella*, were living (p. 79). At other times *Clinodiplosis* larvae have been found apparently living alone in the flower or seed heads of certain plants. Other species of the genus *Clinodiplosis* continually occur among stored seeds and have caused a certain amount of apprehension among those dealing with seed—but

in no instance so far has any damage to such seed been found which could be definitely attributed to the *Clinodiplosis* larvae. In exceptional instances damage to flowers has been associated with *Clinodiplosis* larvae (e.g. see p. 66) and in at least one instance a *Clinodiplosis* has been apparently the causative agent of a blister leaf-gall (see p. 82). On the whole *Clinodiplosis* larvae cannot be considered as pests, but in spite of this attention will be drawn to them because of the fears they arouse among growers and seedsmen.

Nothing really is known as to how many species of *Clinodiplosis* are involved among the ones found in the flowers and seed heads of growing plants, or among those found in stored seed. Biological investigations are badly needed to throw light on such matters.

Another point that should be mentioned in this Preface is the habit among some investigators of naming midges on the larvae and gall, and even on the gall alone. This is much to be deprecated since it is usually most precarious and unwise to associate these names with the midges when they are eventually reared. A plant name followed by the statement "flowers remaining closed and swollen" should never be followed by a generic and trivial name of a new species of gall midge. Yet this has often been done. Several gall midges mentioned in this volume alone have been named on this slender description. Sometimes midges thus named have been regularly recorded by subsequent investigators, who still have only found the gall on the same plant but in different countries. Consequently the rather meaningless name is apt to be perpetuated and faunal lists enlarged by their inclusion as has already been pointed out in the Preface to Vol. II. Midges named in this way have been included in this work, not so much for the name of the midge as to indicate that midges most probably do occur on the various plants. When their presence has been re-discovered the midges should be reared and described properly.

I would like to take this opportunity of thanking Mrs. Stella Roberts and Mrs. Elsa Koller, two assistants in the Entomology Department, Rothamsted Experimental Station,

for their patience and care in deciphering and typing my manuscripts for Volumes I–IV.

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Finally, I wish to thank Mr. Fox Wilson for writing the Foreword to this volume, and also for making valuable suggestions and taking care of a duplicate preliminary typescript of the whole work throughout the war years.

H. F. BARNES.

ROTHAMSTED EXPERIMENTAL STATION.
February, 1946.

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- *Phytophaga violicola* (Coquillet) — Leaves, p. 124
- Unidentified gall midge — Flowers and buds, p. 115

Virginia Creeper (*Parthenocissus* spp.)
- *Dasyneura parthenocissi* (Stebbins) — Leaves, p. 127
- *Lasioptera psederae* Felt — Roots, p. 127

ALYSSUM (*Alyssum* Tourn. ex L.)

No references appear in economic literature to gall midges attacking this plant, which is cultivated both for its perfume and as an ornamental.

However, two species have been recorded in Europe. *Dasyneura alyssi* (Kieffer) was described (190) on the female only. The red gregarious larvae live in a fusiform swelling, the size of a pea, on the stems of *A. calycinum* L. The midges appear in the May following the appearance of the gall, pupation taking place in the soil. This species is only on record from Budapest, Hungary.

The second species, *Janetiella fallax* Kieffer produces a similar gall on *A. arenarium* Gmelin. It was found near Kreuznach, Germany. Kieffer (193) gave full descriptions of both sexes, the pupa, larva, egg and gall. The latter is a stem swelling, about 10 to 15 mm. long and 6–8 mm. wide, on the extremity of a shoot. It is caused by a shortening of the internodal spaces and is covered with leaves. At maturity an opening appears towards the distal extremity. The larvae, which are rosy red, descend to the soil at the beginning of July and the midges appear the following May.

AMARANTHUS (*Amaranthus* L.)

The midges attacking this genus are dealt with in this volume since certain species are cultivated as ornamental flowers (Love-Lies-Bleeding, Prince's Feathers). Other species are commonly used in the tropics for spinach, others as pot herbs in India and others produce edible grain which is used as a cereal in tropical Asia.

In India a single specimen of an unidentified female *Dasyneura* (now in the author's collection) was reared on January 30, 1936, at Pusa by T. Ahmad in a cage containing branches of

Amaranthus which were infested with *Lixus truncatulus*. It is not known on what part of the plant the larvae of this midge feed.

In Texas, U.S.A., Felt (134) described *Asphondylia amaranthi* on *Amaranthus blitoides reverchonii* Uline & Bray. This species is a small *Asphondylia*, the males being 2 mm. and the females 2·5 mm. in length. It emerged in mid-December from galls collected earlier in the month. The gall is formed from the aborted and elongated ovary (232).

Felt (127) stated that *Cecidomyia palmeri* Cockerell is a manuscript name proposed by Cockerell for a gall in the dry stems of *A. palmeri* and the orange larva of which Cockerell (53) briefly described as a *Cecidomyia* species. Felt thought it was probably a species of *Lasioptera*. It has not been found again.

ANTIRRHINUM (*Antirrhinum* Tourn.)

Larvae of a *Clinodiplosis* species (see p. 9) were found by G. Fox Wilson among seed of *Antirrhinum* or Snapdragon* from Slough in November, 1944. Specimens are in the author's collection.

Frequently, the red larvae of a *Mycodiplosis* species occur on *Antirrhinum* rust on which they feed. This species will receive further attention in the appropriate section of Vol. VIII.

AQUILEGIA (*Aquilegia* (Tourn.) L.)

Two species of gall midges have been recorded from Columbine or Aquilegia (*A. vulgaris* L.). The larvae of *Dasyneura aquilegiae* (Kieffer) are red, gregarious and live in the flowers which show little sign of their presence. The species is only on record from Nancy, France, and only the larva has been described (194). The second species has not been identified. Its larvae live on the leaves whose segments are shrivelled and folded. This species is only on record from Italy (309).

ARABIS (*Arabis* L.)

In the literature three names of gall midges appear as attacking this plant, but there is only one species, *Dasyneura*

* See p. 31.

alpestris (Kieffer) Meijere, involved. The other two names, *D. schneideri* Rübsaamen and *D. arabis* Barnes, are synonyms.

Dasyneura alpestris (Kieffer, 1909) Meijere, 1928, the Arabis Midge.

syn. *schneideri* Rübsaamen, 1917; *arabis* Barnes, 1927.

Diagnostic Character. The bases of the leaves in the terminal or central growth of Arabis swollen, enlarged and drawn together, forming a compact open gall (Plate 1, Fig. 1).

Damage. As a consequence of this malformation the whole of the central growth of the plant is often destroyed. Summer generations of the midge attack the terminal points of the shoots and exactly the same type of gall is formed. Weakly side shoots develop. Sometimes the attack develops just as a flowering shoot is developing: in such cases a very malformed flowering stem results (Plate 1, Fig. 2). In no case yet, however, have the larvae been actually in the blossom. On some occasions, although oviposition has taken place, no galls develop. The plants seem to grow away from the attack and the only signs that the plant has been attacked are small round almost transparent areas on the leaves. This may be another instance (see Vol. I, p. 65, and this volume, p. 120) of the rates of development of the plant and midge being different, resulting in the exposure of the eggs and young larvae to direct sunlight. One example of this midge being a pest is its widespread attack during September, 1940, in a public park at Farnworth, Lancashire (G. Fox Wilson, *in litt.*)

Description. Kieffer (194) originally named this midge on the gall only. Much later, Meijere (219) described the larvae, pupae and midges. Rübsaamen (262) also gave a description of this midge under the name *D. schneideri*, while the author (*in* 35) did likewise under the name *D. arabis*. It is a typical average-sized *Dasyneura* species. The number of antennal segments in the male varies from 2 + 13 to 2 + 12, with most individuals having 2 + 13, while the females have 2 + 13 to 2 + 11 with most possessing 2 + 12 (23). The larva is red or flesh coloured.

Synonymy and Historical. The following account is largely

taken from a paper by the author (28), in which he dealt with the identity of the Arabis midge.

The first mention of the gall is in 1886 by Thomas (302) who found it on *Arabis alpina* at Suldenthal in the Tyrol. Later F. Loew (205) reported it from Niederosterreich on *A. hirsuta*. Schlechtendal (268) gave it in his list of German galls and Rübsaamen (253), who in his paper on Russian gall midges considered that the midge forming the gall belonged to the genus *Dichelomyia*, did not actually state that it had been found in Russia. Similar damage to *A. alpina* was next reported from Switzerland by Vogler (314) and Perriraz (233). Kieffer (194) first named the causative agent giving the gall the name *Perrisia? alpestris*. Later, Moreillon (228) reported further damage on *A. alpina* in Switzerland.

Rübsaamen (262) was the first to describe the midges (as *D. schneideri*) in 1917. The red larvae caused identical galls on *A. albida* Stev. (now considered a synonym of *A. caucasica* Willd). These specimens were sent to Rübsaamen by Schneider-Orelli (269) from Zurich. At the same time Rübsaamen mentioned finding larvae, which were white, of a second species in the galls. He did not know the midges of this second species.

Ten years later the author (*in* 35) described the Arabis midge as *D. arabis*, being misled into thinking there were two gall-forming species on Arabis by reason of finding in the galls white larvae which answered Rübsaamen's description of the second species. (This species with white larvae possessing rounded anterior extremities on the breastbone has since been proved to be a species of *Macrolabis* which is only an inquiline. (See INQUILINE, p. 29)

Meijere (219) in 1928 described the midges from specimens reared on *A. alpina* in Holland and, retaining the name *alpestris* Kieffer, called the species *D. alpestris* Kieffer. At the same time he suggested that *D. schneideri* might be synonymous. A few years previously von Poeteren (236) had reported *A. alpestris* Meijere as injurious to *A. alpina* in Holland during 1920.

Doubts as to the distinction between *D. arabis* and *D. schneideri* arose in the author's mind, and he wrote (25): "It seems quite possible that in the future it will be proved that these

two species are identical and that the differences observed between them fall within the range of variation."

The Deshusses (80) reported *D. schneideri* doing extensive damage in Switzerland on *A. albida.* These writers described the midges, gave an account of the biology and recorded they had reared a Platygasterid parasite, *Synopeas* sp. They promised a memoir on the anatomy of this midge.

Later investigations by the author (28) on the host plant range of the Arabis midge showed convincingly that there was only one species involved which should be referred to as *D. alpestris* (Kieffer) Meijere (= *schneideri* Rübsaamen et *arabis* Barnes). Midges reared from different species of Arabis obtained in different localities were successfully cross-mated and bred on different species of *Arabis.* Thus, for example, a Kew male from *A. alpina* var. *rosabella* fertilized a German female from *A. alpina* and the succeeding offspring bred on *A. caucasica.* Other examples are given in the same paper.

DISTRIBUTION. Germany, Austria, Switzerland, Holland, Sweden (317) and England. In the last-named country it was first found in Surrey by G. Fox Wilson in 1922 (25). Later it was recorded from Middlesex, Hertfordshire and Cambridge (28). More recently, in September, 1940, it has been found occurring abundantly in a public park at Farnworth, Lancashire (G. Fox Wilson, *in litt.*).

LIFE HISTORY. The biology of this midge has been studied by the Deshusses (80) and Barnes (25, 28).

The eggs are red and are tucked away, as deep as possible without penetrating the tissue, in the leaf buds among the hairs of the leaves. The larvae are flesh coloured or red. Their anchor process or breastbone has pointed anterior extremities. The larvae remain in the gall throughout their feeding period. When full-grown some leave the galls and pupate in the ground, while others spin white cocoons in which they pupate inside the galls. More male than female midges emerged from the soil than from the galls in the author's experience. Those which pupated in the soil, however, started emerging a day or two after those which had remained in the galls. This may be accounted for by the faot that the temperature in the galls in

the summer is likely to be higher than that in the soil and so the development of the pupae may be slightly slower in the soil. As many as 98 larvae and cocoons have been found in a single gall, but the usual number is 20–30. No exact information is available as to the duration of the egg, larval and pupal stages nor the time necessary to lapse before the galls become visible.

There are several probably overlapping generations a year, the last generation and occasionally part of the penultimate overwintering in their cocoons on the plants or in the soil.

Under unheated insectary conditions at Harpenden on *A. caucasica* (*albida*) the author obtained three generations in 1930 and 1931 and four generations in 1929, 1932 and 1933.

The first flight of the midge usually occurs in May, the second in late June to early July, the third in August and the fourth in September. The actual first date of this midge on the wing under these conditions was April 6 in 1938, the next earliest being April 17 in 1933. The latest known dates of emergence at Harpenden are October 29 in 1937 for English material and November 18 in the same year for material received from Kiel, Germany, during September.

The sex ratio at emergence seems to vary in the different generations. As the season advances the percentage of males decreases. On the whole, the first generation of the year has the highest percentage of males, the second less and the third and overwintering generations the least. This is the reverse of what was found (see Vol. III, p. 131) in the case of the Pear Leaf Midge, *D. pyri* Bouché. In this species as the season advances the percentage of males increases. The sex ratio over the period 1929–33 involving 11,462 emergences was 27 : 73 but varied from 3 to 97 in the fourth generation of 1932 to 51 : 49 in the first generation of 1930. It is influenced by the time when the females are fertilized, delayed fertilization appearing to send up the number of males in the ensuing family. Experiments (20, 25) have also shown that there are male-producing families and female-producing families in addition to families which produce individuals of both sexes in approximately equal numbers. The occurrence of unisexual families is not usual in this species.

The prevalence of damage varies considerably from year to year. For example, in the early autumn of 1937 the galls were exceedingly plentiful, especially in Harpenden, whereas in 1938 they were rather conspicuous by their absence. This particular example of a decrease in numbers may be accounted for by the prolonged emergence in the autumn of 1937 reducing the number of midges which were in a suitable stage to overwinter successfully, and by the exceptionally early emergence in 1938 followed by frosty weather which probably still further reduced the midges.

FOOD PLANTS. *Arabis* species of the subgenus *Euarabis* and possibly *Lomaspora*, i.e. *A. alpina* L., *A. alpina* L. var *rosabella*, *A. aubrietioides* Boiss., *A. caucasica* Willd. (*albida* Stev.) and *A.* (*Lomaspora?*) *stelleri* DC. var. *rosea*.

In the literature *A. hirsuta* Scop. is also recorded as being attacked by the midge.

The author (28) made a study of the host plant range of this midge, observing which species of *Arabis* were suffering from midge attack in the Royal Botanic Gardens, Kew, and experimenting with species of *Arabis* belonging to various subgenera. Species of the subgenera *Pseudarabis*, *Turritis*, *Drabopsis*, *Turritella* and *Drabina* were not attacked at Kew; whereas the species of the subgenus *Euarabis* mentioned in the previous paragraph were. Likewise in experiments, while the midge bred on *A. alpina*, *A. aubrietioides* and *A. caucasica* it would not oviposit or breed on *A.* (*Drabopsis*) *carduchorum* Boiss., *A.* (*Turritella*) *hirsuta* Scop. var. *glabra* L. (Lange), *A. laudaurii* (*A. bellidifolia* × *ferdinandi coburgi*), *A.* (*Pseudarabis*) *procurrens* Waldst. & Kit. and *A.* (*Drabina*) *scopoliana* Boiss.

NATURAL ENEMIES: PREDATORS. The author (25) recorded that the larvae of the garden carpet moth (*Xanthorhoë fluctuata* L.) ate out the galls of this midge, but it is not known whether or not they actually ate the midge larvae. In either case such an attack if made when the midge larvae were small would prevent the midge from developing.

A *Lestodiplosis* sp. was recorded in the same paper and an earlier one (35) as being predaceous on the larvae of this midge.

NATURAL ENEMIES: PARASITES. The Deshusses (80) recorded

a *Synopeas* sp. (Platygasteridae) parasitizing this midge in Switzerland. The author (25) mentioned that a single specimen of *Misocyclops marchali* Kieffer had been reared. Later (28) he recorded the Eulophids, *Tetrastichus annulatus* Först (reared from German and English material) and *Omphale aetius* Walker (reared from English material); and the Platygasterids, *Synopeas* sp. n.? and *Piestopleura catillus* Walker (both reared from English material).

INQUILINE. The author (28) recorded breeding a species of *Macrolabis* from the galls of *D. alpestris*. This species almost certainly provides the clue to the white larvae mentioned by Rübsaamen (262) and their supposed adults described by the author as *D. arabis* in 1927.

This *Macrolabis* is represented in the Barnes collection by a Hertfordshire male and female. The larva is white with rounded anterior extremities on the breastbone.

CONTROL MEASURES. Theobald (*in* 35) advised pruning the plants as soon as the galls become conspicuous and in addition dressing the beds with 4 oz. of naphthalene to the square yard or with one of the patent soil insecticides.

It might be worth while experimenting with the application of such substances as ethylene dichloride emulsion and with paradichlorobenzene.

MATERIAL. Males and females, England (Surrey, including the type and paratype male and 6 cotype females of *D. arabis*) and Germany (Kiel, Badsooden-Allendorf and Breslau). Pupa, Germany (Badsooden-Allendorf). Larvae, England (Hertfordshire, Surrey) and Germany (Kiel).

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ASCLEPIAS (*Asclepias* L.)

Only one gall midge, *Monilipennella trapezospatha* Del Guercio (78), has been recorded in economic literature as occurring on Asclepias. The larva is bright golden yellow and lives in a terminal shoot gall on *Asclepias* sp. in Eritrea.

In the United States of America four species of gall midges have been found on *Asclepias* or milkweed (121). *Neolasioptera asclepiae* Felt (103) forms an elongate fusiform stem gall on swamp milkweed, *A. incarnata* L. It was found at Albany, N.Y., and the midges emerged in late June. The female, gall and larva have been described (120). Felt also recorded (106) two undescribed species of the genus *Cecidomyia* on this same plant species; the one from "rusty brown, irregularly swollen young leaves", the other from an "oval, mid-rib, tumid fold, length 7 mm., diameter 4 mm.". The fourth American species is *Lestodiplosis asclepiae* Felt (103) which was reared in early August from rolled leaves of *A. cornuti* Decne (*syriaca* L.), containing whitish larvae, found at Highland and Albany, N.Y. This is probably a predaceous form. Only the male has been described in detail (125).

Two other gall midges occur in Europe on *Cynanchum vincetoxicum* Pers. (*A. vincetoxicum* L.). *Contarinia asclepiadis* (Giraud) was originally described by Giraud (152). The white larvae live gregariously in the seed follicles during July and August in central Europe. Sometimes the follicles are slightly swollen. When the larvae are full grown they "jump" to the soil. Emergence takes place the following June. The second European midge is on record from Germany on *Vincetoxicum officinale* Moench. (= *A. vincetoxicum* L.) and is *Contarinia vincetoxici* Kieffer (194). The white larvae live in the flowers which are swollen and remain closed. Metamorphosis takes place in the soil (147). The midge itself has apparently not yet been described.

ASPHODEL (*Asphodelus* (Tourn.) L.)

No species of gall midges has been recorded as definitely causing damage to Asphodel, but two species have been

associated with this plant. *Silvestrina asphodeli* Barnes was reared by F. Silvestri, in company with *Lestodiplosis asphodeli* Barnes, from the dry infloresences of *Asphodelus* at Cagliari, Sardinia. Larvae of *Silvestrina* species are usually predaceous on mites or coccids and, since Silvestri cannot state definitely to the contrary, it is suspected that the larvae of *S. asphodeli* were probably feeding on some mite (or coccid). Similarly, larvae of *Lestodiplosis* species are normally zoophagous. The larvae of *L. asphodeli* were therefore probably feeding on the larvae of *S. asphodeli* or on some other insect or mite. Both sexes of these two species were described by the author (24) and the original material (7 males and 4 female cotypes of *S. asphodeli*; 6 male and 6 female cotypes of *L. asphodeli*) is in the Barnes collection.

BALSAM (*Impatiens* Riv. ex L.)

In Java Docters van Leeuwen-Reijnvaan (89) described a leaf roll, containing white larvae, on *I. platypetala* Lindl. Felt (124) named this midge *Thorodiplosis impatientis* Felt and described both sexes.

In Europe a single species, *Clinodiplosis impatientis* Kieffer (190), has been recorded on *I. noli-tangere* L. (Touch-me-not in England). The larvae were found in swollen flowers at Bitsch and the midges emerged the following year during July.

In the U.S.A. and Canada three species have been recorded attacking *I. fulva* (American popular names: Jewel-weed, Touch-me-not or Snapdragon *). A fourth species, *Mycodiplosis impatientis* Felt (see Vol. VIII), has been described from a stem infested with *Aecidium impatientis*. The larvae of *Lasioptera impatientifolia* Felt live in a tumid leaf fold along the midrib (121). The male and female were originally described (99) and later redescribed together with short descriptions of the gall and larva (120). Felt found the gall at Albany, N.Y., Stebbins (281) found it near Springfield, Mass., and Jarvis (178) recorded it from Ontario. Felt (120) stated that *Eupelmus dryorhizoxeni* Ashm., was reared from the gall of this midge.

The other two North American species are known only on

* See p. 23.

the gall and larvae. *Cecidomyia fulva* Beutenmüller causes a globular succulent swelling on the stem, petiole or leaf of *I. fulva*. Beutenmüller (38) described the larva as being orange and living solitarily in the gall. It was collected in New York and New Jersey. *Cecidomyia impatientis* Osten Sacken (231) causes a green almost globular gall about half an inch in diameter formed at the base of the flower of *I. fulva*. It contains numerous larvae. Walsh (322) first figured the gall and larval breastbone. This gall is more widespread than the former, being found both in Canada and the U.S.A. Beutenmüller (37) recorded finding this gall on *I. pallida*. Full references to both these galls are given by Felt (127).

BOX (*Buxus* L.)

One species of gall midge attacks plants of this genus and is sometimes a pest of considerable importance.

Monarthropalpus buxi (Laboulbène, 1873), the Box Leaf Mining Midge.*

DIAGNOSTIC CHARACTER. Blisters on the leaves of Box.

DAMAGE. The first signs of attack are small yellowish or light-green spots on the upper surface of the leaves. Later irregular oval blisters appear on the lower surface. There are also frequently slight elevations on the upper surface. These blisters often exhibit a yellowish or brownish discoloration. In bad infestations there are several blisters on a single leaf and sometimes the whole leaf assumes a puffed or swollen appearance. When the larvae are about full grown, circular spots, or "windows", appear on the lower surface of the leaves, these spots consist of the epidermis only of the leaves and are transparent. Chaine (50) made a study of the gall development.

As a result of the larvae feeding on the leaf tissues, the leaves drop off prematurely. Normally they remain on a shrub or bush for several years, but when attacked by the midge they usually fall after about a year. In bad infestations the whole

* Also known as the Box Midge, the Box Leaf Midge, the Box Leaf Miner, the Boxwood Leaf Midge, the Boxwood Leaf Miner (this is the official common name in America (230)).

PLATE I.

Fig. 1.—Typical Gall of the Arabis Midge, *Dasyneura alpestris*, on *Arabis caucasica*. (*Photograph by N. K. Gould*)

Fig. 2.—Gall of Arabis Midge at Base of Flowering Stem of *Arabis caucasica* resulting in Malformed Shoot. A normal flowering shoot is to the right. (*Photograph by V. Stansfield*)

PLATE 2.

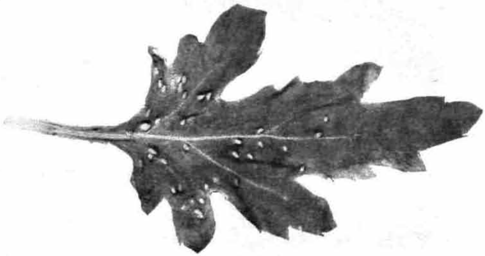

Fig. 1.—Gall of the Chrysanthemum Gall Midge, *Diarthronomyia chrysanthemi*, on Chrysanthemum Leaf. (*Photograph by V. Stansfield*)

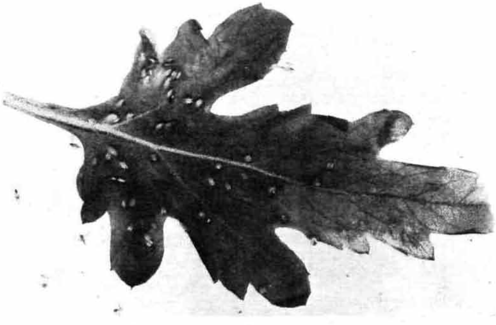

Fig. 2.—The Same Leaf showing emerging Midges. (*Photograph by V. Stansfield*)

plant becomes undernourished because the young and active leaves are attacked and, instead of having a thick dense foliage, its growth is poor and the foliage thin. This is serious and unsightly in an ornamental bush and hedging plant. Occasionally bushes have been killed outright as a direct consequence of a severe infestation. It is particularly serious when nursery stock becomes infested.

DESCRIPTION. This is one of the earliest known midges in historic times. Geoffroy (148) figured the galls and the midges and, described the latter, using the names *Scathopse flava*, le Scathopse du Bois. Laboulbène stated that Winnertz, Loew and Schiner had on various occasions described it as new. The author has not traced these references. The first investigator to name this species under the binomial system was Laboulbène (199), who gave a remarkably exact and correct account of its biology, describing each stage as well as illustrating admirably the larva, pupa, gall and midge, the latter in colour. Rübsaamen (251) erected the genus *Monarthropalpus* for this species. Chaine (50) described the morphology of the egg, larva, pupa and midge in detail. More recently, Felt (112, 125) described both sexes and in the first citation the empty pupal case and hibernating larva in addition. Hamilton (160), quoting Felt's descriptions of the male and female, gave new descriptions of the egg and four larval instars.

The midge is yellowish orange and the female is characterized by the possession of a curved chitinous spine, which has a length about one-half the diameter of the abdomen, at the distal extremity of the latter. The larva, which is whitish or orange according to age and about 2·5 mm. in length when full grown, is outstanding among gall midges by reason of its leaf-mining habit.

DISTRIBUTION AND HISTORICAL. Europe and the United States of America.

It was known in France as long ago as 1764 by Geoffroy and was probably also known by Winnertz, Loew and Schiner in other parts of Europe. It was studied at Paris by Laboulbène in 1867–73 and by Decaux about 1890. Chaine later studied it during a serious outbreak at Bordeaux in 1910–13. Brühl (46)

stated it was first recorded from Germany in 1911 and studied it in a serious outbreak at Bonn in 1927. In Holland apparently the first record is that of Ritzema Bos (243), it was reported in 1900 from Italy (14) and it first appeared in Denmark in 1933 (6). It has also been recorded from the Tyrol and Vorarlbergs (70, 71) and Switzerland (269).

In England it has been known to occur at least since 1892 (298) and probably is to be found in most counties where Box is grown. Definite county records include Yorkshire (10), and Middlesex, Northamptonshire, Berkshire and Hertfordshire in the author's experience.

In the United States of America it appeared first in 1910 at Kingston, Rhode Island (105). It appeared in Long Island during 1912 (318), in Maryland in 1913 (60), near New York City about 1913 (129), New Jersey in 1914 (329) and in the San Joaquin Valley, California in 1915 (275). Britton (45) and Dozier (92) reported it respectively from Connecticut and Delaware. It is generally understood that it was imported from Europe, Maskew (213) having intercepted it on plants from France and Weiss (330, 331) and Sasscer (265) having reported taking it at various times on boxwood from Holland.

LIFE HISTORY. Good accounts of the biology of the species at Paris have been given by Laboulbène (199), at Bordeaux by Chaine (50), in Maryland by Hamilton (160) and in Michigan by Ries (241). The localities are useful in view of the dates in the seasonal life history varying in the different localities, in addition to the slight normal variation from year to year.

The eggs are laid inside the leaf in the spring. The female midge bores with its ovipositor through the epidermis working from the lower surface, eventually placing the egg nearer the upper surface than the lower. The upper leaf surface seems to be impenetrable by the midge. Laboulbène described the act of oviposition as taking 12–14 minutes and consisting of two distinct parts. For about 6 minutes the female pushes her ovipositor into the leaf with an in-and-out movement. Then after a rest continues with a rotary movement. Chaine and Hamilton both mention a side-to-side movement, the latter investigator stating that the time for one egg to be laid is

3–8 minutes, while Chaine gives 4–9 minutes. Although the act of piercing the leaf is obviously hard for the midge, Laboulbène seems to have exaggerated the time taken. The author's own experience shows it takes about 7 minutes. Oviposition usually takes place on the young leaves and more eggs are laid in the proximal half of the leaf than the distal. The oviposition period is 2–3 weeks. The number of eggs laid per leaf varies from 1 to 17 according to the degree of infestation, the most usual number of larvae found being 6–12. The actual number of eggs laid by a female in the field is not known, but under laboratory conditions it has been given as averaging 29 (158) and 33 (241). Dissections have revealed 50–75 eggs in newly emerged female midges. The duration of the egg stage is from 2 to 4 weeks, averaging about 3.

The larvae mine between the leaf surfaces and take about 10 months to become mature. The first instar remains curled up in the place where the egg was placed. Ries states this instar lasts about 4 weeks. The second instar starts to mine, feeding in the tissue, and this stage continues about 6–10 weeks according to Ries. Probably an enzyme is secreted as the surrounding cells become enlarged at this stage in the midge's development. When several larvae occur in a single leaf the mines converge, several larvae instead of a single one being found per blister which may cover most of the leaf area. No excreta is found in these blisters. Larval mortality is sometimes heavy during the summer months. On occasion the larvae die without any apparent cause, at others they dry up through lack of sufficient moisture. This occurs in hot dry summers. Often also one finds larvae of different sizes in a leaf and the smaller ones (i.e. those derived from later laid eggs) frequently perish. The third larval instar is reached by the autumn and the winter is passed in this stage. Cold does not seem to cause any mortality. The fourth instar appears about a month before pupation in the spring and lasts 2–3 weeks, according to Ries. When the larvae are about full grown, circular transparent "windows" through which the pupae will protrude half-way on emergence of the midge become noticeable. Most investigators are of the opinion that each larvae makes one of these "windows" just before

pupation. Chaine, on the other hand, considered them to be the result of the original egg puncture, since he did not always find a "window" per larva. This does not seem likely. There nearly always appears to be a "window" for each pupa. Often the pupae fall out through the "windows" to the ground, apparently because they wriggle out too quickly. Such fallen pupae sometimes produce normal midges. Typically, the pupa pushes out half-way and then emergence of the midge takes place leaving the empty pupal case protruding. The pupal stage lasts about 3 weeks.

The midges are stated by Laboulbène to emerge between 6 and 7 a.m., but Chaine stated that he had seen emergences throughout the day, particularly between two and four in the afternoon. Mating occurs almost immediately and oviposition starts soon after. The midges in calm weather may be seen hovering round the bush from which they have emerged and do not fly far away. They usually only live up to 3 days, but Ries said they will live 7–10 days in calm weather.

The seasonal life history can be summarized as follows: emergence takes place in the spring and usually continues for about a fortnight. In the U.S.A. Smith & Fisher (273) stated that emergence takes place about the time of the first appearance of blooms on Weigelia and Mock Orange and the showing white of the blooms of Snowballs (*Viburnum opuli-sterilus*). The accuracy of this phenological observation has not yet been checked in England, but it is probably quite an accurate and useful indication of the emergence period of the midges.

The author has only had limited experience of rearing this midge in England, but in 1931 midges emerged at Harpenden from May 27 to June 3 and in 1932 midges continued emerging until June 14. He has also received mature larvae from Northamptonshire on April 2, 1935, mature larvae and pupae from Middlesex on May 3, 1930, and emerging midges from Berkshire on May 2, 1931.

Laboulbène states emergence took place in May in Paris and Chaine states that it took place at Bordeaux in the first fortnight in April, giving the first emergence date in 1910 as April 13; in 1911, March 24; and in 1912, April 16. Hamilton

gives the date of the first emergence at Baltimore, Maryland, U.S.A. as follows: 1913, May 15; 1916, May 10; 1920, May 21; 1921, April 22; 1922, May 8; 1923, May 15; and 1924, May 16; while Ries gives late May as the usual period in Michigan.

The first larval instar is to be found during the early summer months; from June to the middle of July or first of August in Maryland. The second instar continues until the autumn when the third instar appears; about the middle or end of September in Maryland. This stage lasts until the spring and the emergence "windows" which appear in the spring are probably made by this stage just before developing into the fourth instar but perhaps are made by the fourth-instar larvae. The fourth-larval instar appears in the spring; during the middle to late March in Maryland. Pupation occurs about a month later (mid-April in Maryland) and lasts about 3 weeks.

The actual dates of the different stages appear to be slightly earlier in Bordeaux than in Paris, in Maryland than in Michigan. There is also some variation from year to year in any one locality as to be expected.

There is only one generation a year, although Decaux (77) in France mentions finding pupae in July, thus showing the possibility of, for this species, a very unusual partial summer emergence.

Food Plants. Chiefly *Buxus sempervirens* L. Also *B. balcariaca*, *B. variegata*, *B. variegata argentea* and *B. variegata aurea*, but not *B. latifolia*, in the experience of Chaine (50). The Deshusses (79) reported it on *B. sempervirens*, *B. angustifolia*, *B.* var. *hansworthi* and *B. variegata aurea* in Switzerland. In England it has occurred on the common Handsworth and variegated varieties in Middlesex (G. Fox Wilson, *in litt.* 2.5.30). In Maryland, U.S.A., Cory & Graham (62) recorded it on *B. sempervirens*, *B. suffruticosa*, *B. arborescens* and *B. rotundifolia*.

Resistant Varieties. All the above-named species and varieties are much less commonly attacked than *B. sempervirens*. This may be due to some resistance, such as toughness of the leaves, or it may be an illusion due to the fact that *B. sempervirens* is much more commonly grown. *B. latifolia* may possibly be immune.

Natural Enemies: Parasites. On very few occasions have parasites been recorded. Laboulbène, Chaine and other investigators have never found any, but Decaux (77) recorded the emergence of a Chalcid. Hamilton (160) also records finding pupae resembling those of a Chalcid in the galls.

Natural Enemies: Predators. On the other hand, there are several efficient predators. Ants are recorded by Chaine (50) eating the pupae as they stick out of the "windows" of the galls just prior to the emergence of the midges. Hamilton (160) also records ants as entering through the pupal holes and feeding on any remaining larvae or pupae.

A correspondent of G. Fox Wilson (*in litt.* 2.5.30) has observed blue tits feeding on the larvae in Middlesex and this is confirmed by the author, who watched tits picking out the larvae from infested leaves at Harpenden during the early spring of 1938. The birds apparently could hear the larvae moving inside the leaves; they were in fact quite audible to the human passer-by (see p. 42). It was dry, frosty weather.

Chaine (50) also recorded birds feeding on the midges as they swarmed round the bushes.

Control Measures. Dusting, spraying, fumigation and hot water immersion have all been recommended as means of controlling this midge. Dusting has never been strongly recommended probably because of the difficulty experienced in covering efficiently all the leaves, but with more modern methods it may gain in importance. Both dusting and spraying, however, can only be carried out during one period of the year, when the midges are emerging, and depend rather much for their efficiency on the amount of care taken to reach every leaf and the frequency of their application. In neither case can one expect a complete control. Both methods aim at the prevention of successful oviposition, the former by creating a mechanical barrier to oviposition, the latter by killing the midges. Spraying, however, is to be recommended for owners of small or moderate quantities of Box. This is especially true in cases where neighbours likewise have Box since spraying also serves to protect the plants against new infestations. Fumigation and dipping are very efficient means of control

and can be done at several seasons of the year since they'aim at killing the larvae in the galls. Fumigation requires proper equipment, suitable working conditions and skilled personnel. Dipping requires that the plants are dug up and is probably most suitable for growers preparing stock for sale or replanting their stock in clean blocks in their own nurseries.

Hamilton (160) reviewed the methods of control up to the time he was writing as did also Brühl (46). Middleton & Smith (221) give admirably illustrated and most up-to-date detailed instructions for spraying, fumigation and immersion in hot water.

Dusting is not now usually recommended as a control measure, but dusts and other dirt in small particles act as mechanical barriers to oviposition. Chaine (51) first noticed that Box growing alongside roads was not usually attacked by the midge (cf. Vol. III, p. 27). After experimenting with various substances, he found the following procedure gave the best results. First, wet the undersurface of the leaves thoroughly with water by means of a spray apparatus. Immediately afterwards apply flowers of sulphur with bellows. The particles will adhere to the wet surface of the leaves and prevent oviposition to a large extent. It was necessary to repeat this treatment once or twice during the oviposition period owing to the particles being removed by wind, rain and the growth of the leaves. Even so some eggs would be laid successfully on leaves that had escaped dusting, and Chaine recommended examining bushes about the end of January and beginning of February and removing any infested leaves. He stated it was not necessary to destroy such leaves as the larvae could not go on developing in leaves separated from the branches. Weiss (330,333) went even so far as to recommend the destruction of infested bushes. Smith & Fisher (273) reported obtaining a good control by the daily application, during the emergence period, of a dust of 40 per cent. nicotine sulphate and kaolin or hydrated lime (1 : 20).

Spraying frequently as the midges were emerging with soluble sulphur at the rate of 4 lb. to 50 gals. of water was found by Walker (318) to result in good kills of the midges.

Felt (112) reported that Professor Stene of Rhode Island had got fairly good results with contact insecticides such as kerosene emulsion and whale oil soap solution when the midges were emerging. Cory (61) introduced spraying with molasses in order to entangle the midges as they emerged. He found that large numbers were caught when the strength used was 4 lb. of molasses to 50 gals. of water. Hamilton (158) found 1 part of molasses to 3 parts of water successful if applied three times during the emergence period and more frequently if rain fell. He also experimented in the laboratory and found that it was beneficial to incorporate contact insecticides, such as pyrethrum or nicotine, in order to kill quickly the entangled midges. Later (160), he found the most satisfactory formula was 1 part molasses to 4 parts water with 40 per cent. nicotine sulphate, 1 part in 500. The spraying should be done at considerable pressure with a short rod bearing an angle nozzle. Three applications should be sufficient at intervals of about 5–6 days if rain does not intervene. He suggested covering the bushes with canvas or thick muslin just before rain to conserve the spray and avoid the necessity of re-spraying directly after rain. Primm & Hartley (237) found that spraying with a heavy emulsifying petroleum oil went far to counteract the lack of cheapness and the little resistance to weather of the molasses. They used 1 part oil to 20 of water with the addition of 1 pint of Black Leaf 40, to 50 gals. of the spray mixture, and stated that even after 48 hours of hard rain it was not necessary to spray again. They suggested two such sprayings about a week apart and recommended low pressure spraying. Hamilton (160), however, found this method caused considerable scorching. Finally, Middleton & Smith (221) give the following formula for spraying: molasses 1 gal., water 5–6 gals., nicotine sulphate (40 per cent. nicotine) 8 to 10 teaspoonfuls. The bushes should be kept sticky throughout the emergence period. This necessitates a careful watch being kept for the first midges' emergence and spraying at 4-day intervals, unless rain intervenes or the bushes are covered, for about 2 weeks. They suggest clipping the new growth in order to round off this control.

PLATE 3.

Galls on the Chrysanthemum Gall Midge on Badly Infested Stem. (After Cameron, *photograph by M. J. M. Noble*)

PLATE 4

Distorted Stems and Buds due to Severe Infestation by the Chrysanthemu Gall Midge; *(inset)* the Female Midge *(highly magnified)*. *(Photographs by A. Buckhurst)*

D.D.T. appears to be effective against this midge. Rünyon (343) recorded that results obtained during 1945 suggested that excellent control can be obtained if proper concentrations are applied as soon as the heads of the pupae turn brown. He mentioned even as low a concentration as 1 part D.D.T. in 4,000 parts of water. Similarly, Pyenson (342) has shown its effectiveness, both as a wettable spray powder diluted at the rate of 2 lb. of actual D.D.T. per 100 gals. of water plus a sticker-spreader, and as a 20 per cent. solution in a miscible summer oil diluted 1 to 100 with water, also when used just before the emergence period. The fact that the emerging midges appeared to be affected through foot contact with the treated surfaces suggests that D.D.T. treatment may prove to be extremely efficacious against any gall midge which emerges from galls on leaves, e.g. the Chrysanthemum Gall Midge and the European Violet Leaf Midge. It might appear at first that D.D.T. would not necessarily be so effective against gall midges emerging from the soil, since the midges might succeed in laying some eggs, e.g. within closed blossom, etc., before contact with the D.D.T. on the surface proved lethal. But in the case of at least two gall midges which emerge from the soil, e.g. the Black Currant Leaf Midge and the Raspberry Cane Midge (see Vol. III, pp. 53 and 67–8) good control has already been claimed for D.D.T.

Fumigation if properly done affords a complete control. Felt (115) conducted laboratory experiments and found that with carbon bisulphide and hydrocyanic acid gas he obtained a good kill of the larvae in the leaves without foliage injury. Carbon tetrachloride and flaked naphthalene caused the larvae to become quiescent but they recovered, while ammonia killed the larvae and scorched the leaves badly. Hamilton (158) also made laboratory experiments with carbon bisulphide and hydrocyanic acid gas, but came to the conclusion (160) that fumigation was not practicable owing to the difficulty and cost of application under field conditions. Smith & Fisher (273) first described the fumigation method as used nowadays. Wooden frames, 4 × 5 × 5 feet, covered with canvas enclosing 100 cubic feet, were used. The dosage for this area is 2 oz. of

sodium cyanide in 6 oz. of water and 3 oz. of sulphuric acid. The fumigation must be done when the plants are dormant (November to March) and dry since the presence of moisture causes damage to the foliage. The outside temperature should be between 40° and 55° F. since a higher temperature will cause the temperature inside the tent to become sufficiently high to cause plant injury. Temperatures of 75° F. and above inside the tent are too high for safe fumigation. Death of the larvae is slow. Larvae fumigated in November appear normal until March and then die in April. If the plants are treated in the spring, the death of the larvae occurs in May or early June. Smith & Fisher do not recommend the fumigation of plants for shipment. Middleton & Smith (221) give exact instructions for fumigation and also an illustration of fumigation tents.

An interesting offshoot of fumigation is the auditory method of testing its efficiency developed by Middleton & Smith (220). They found it more reliable than larval examination since after fumigation the larvae are motionless. After a few days, however, if and when the leaves are opened the larvae will squirm about although they are going to die eventually. This is apparently due to the stimulus of opening the leaves and exposing the larvae to the air. If one listens close by infested bushes a faint rustling can be heard on sunny warm days if the larvae are alive; on the other hand, if the bushes have been successfully fumigated there is no sound (see p. 38).

Immersion in hot water also provides a complete control. The infested plants have to be lifted, their roots being covered and balled. This makes the dipping method useless for ornamental plantings of Box but valuable for nurserymen. The midge larvae vary in their resistance to heat according to the season and their stage of growth. The plants also react differently according to the season of the year. If the treatment is done in the spring before the buds begin to swell, the plants grow very well after the dipping and transplantation. If it is done late in the spring after the buds have swollen temporary damage is done to the foliage, but after autumn dipping there is considerable mortality following the treatment. Smith,

Fisher & Guyton (274) were the first to test this method. They found that spring dippings injured the young new growth and buds, but such plants had recovered by midsummer. In addition the foliage of treated plants might be bleached by the sun but this could be avoided by shading the plants on the south and west sides. Satisfactory control was obtained if the plants were immersed for 10 minutes at 120° F. during July and August, for 7 minutes in early September and for 5 minutes in the last half of September and October. They gave a table showing how the temperature of the water and period of immersion could be altered. Cory & Graham (62) proved the practicability of such treatment by dipping 2,430 plants of four varieties of *Buxus* ranging from 1 to 3 feet in size in hot water at 120° F. for 5 minutes in the spring, before the buds started to swell. The cost, including equipment, worked out at about 4*d.* per plant and the injury was only slight and temporary. Cory, Graham & Langford (63) showed that whereas dipping was safe in the spring when the mild weather had set in and before emergence of the midges had started, autumn dipping was inadvisable. Up to 73 per cent. of the treated bushes died in one case following autumn treatment. Although 8 per cent. died and 2·9 per cent. showed commercial damage following spring dipping, this was attributable to other causes not associated with the immersion. In these investigators' experiments the cost was 5*d.* to 10*d.* per plant which was partly due to the fact that the plants had to be transported a distance of 5 miles. Different types of equipment are described in this paper. Middleton & Smith (221) give implicit instructions for the hot-water immersion method.

The last-mentioned authors also emphasize the fact that control of this midge is a community problem and every owner of Box should co-operate in its control by keeping his own Box treated.

Material. Males and females, England (Berkshire). Pupae, England (Berkshire, Middlesex). Larvae, England (Berkshire, Hertfordshire, Middlesex, Northamptonshire).

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BRIDELIA (*Bridelia* Willd.)

B. micrantha (Hochst.) Baill. of Tropical Africa is the food plant of the "Anaphe" silkworm.

Felt (123) described the female only of a gall midge, *Toxomyia brideliae* Felt, which causes a leaf gall on *B. stipularis* Blume and was found in the Philippine Islands.

In Java Docters van Leeuwen-Reijnvaan described two galls made by unidentified gall midges on *Bridelia*. One, on *B. stipularis*, is a definite gall about 2–3 mm. in size on the lower surface of the leaves and scarcely visible on the upper surface (85, 86). The other, on *B. tomentosa* Blume, is a bud gall, terminal or axillary, in which the bud is swollen and contains a single larva (87). Both these galls are figured by Houard (174).

BUDDLEIA (*Buddleia* Houst.)

The only midge described from Buddleia is *Asphondylia buddleia* Felt. Both sexes were described (134). They were reared from aborted ovaries of *B. racemosa* Torr. found at Austin in Texas, U.S.A. Painter (232) described the gall as being formed of the enlarged and slightly thickened corolla, the top being united as in the bud. A single larva is found in each.

CEANOTHUS (*Ceanothus* L.)

Two gall midges have been recorded from Ceanothus. The California Lilac * is a *Ceanothus* species. *Asphondylia ceanothi* Felt was discovered and reared by A. Koebele in 1888 at Oakland, California (103). The gall is an enlarged, loose terminal bud, about 2 cm. in length and 1·5 cm. in diameter on *C. velutinus.* It is thickly covered with long hairy leaflets. The midges emerged in June. The female was described in detail in 1916 (119), while the male was described as recently as in 1934 (131). This latter specimen was reared by Miss Hildebrand from a flower bud gall on *C. cuneatus* near Mt. Konocti, Lake County, California.

Felt also (121) recorded a thickened vein-fold as being caused by an undescribed *Cecidomyia* species.

CHINA ASTER (*Callistephus hortensis* Cass.)

Males and females of a *Clinodiplosis* species, now in the Barnes collection, were reared by the author from larvae found among China Aster (*C. hortensis* Cass.) seed by L. Ogilvie during October, 1934. These midges emerged at Harpenden in an outdoor unheated insectary from May 23 to July 6, 1935. A female *Lestodiplosis* was reared from the same material (see p. 9).

CHRYSANTHEMUM (*Chrysanthemum* (Tourn.) (L.)

One species of gall midge, *Diarthronomyia chrysanthemi* Ahlberg, is a serious pest of cultivated chrysanthemum. For many years this species has been confused with another very closely allied species, *Rhopalomyia hypogaea* (F. Loew), which attacks wild species of *Chrysanthemum.* This latter midge will be considered in Vol. VIII, in which the gall midges attacking weeds are considered. Information will also be found there on other gall midges which live on wild *Chrysanthemum* species. They include, among others, the following gall midges—*Clinorrhyncha leucanthemi* Kieffer, *C. chrysanthemi* H. Loew, *C. tanaceti* Kieffer,

* *Syringa vulgaris* L. is the Lilac.

Rhopalomyia tanaceticola (Karsch) and *Contarinia chrysanthemi* (Kieffer).

Several other species have been associated with *Chrysanthemum* in Japan (226). Whether or not these species were found on cultivated *Chrysanthemum* cannot be stated since the entire paper with the exception of the names of the midges is written in Japanese. These names of the midges described include amongst others *Cecidomyia hypogaea* Monzen and *Rhopalomyia chrysanthemum* Monzen.

Diarthronomyia chrysanthemi Ahlberg, 1939, the Chrysanthemum Gall Midge.*

syn. *hypogaea* F. Loew of Felt (118), *inter aliis*, nec *hypogaea* F. Loew, 1885, of F. Loew.

Diagnostic Character. Oval or cone-shaped galls, about $\frac{1}{10}$ inch or 2 mm. long, usually projecting obliquely, on the leaves, stems, buds and calyxes of autumn commercial chrysanthemums (Plate 2, Figs. 1 and 2).

Damage. In a slight attack the galls are usually scattered over the upper surface of the leaves, but in severe infestations the galls are to be found on both the upper and lower surface of the leaves and on the stems, buds and calyxes as well (Plate 3). The leaves are badly distorted, the stems swollen, twisted and malformed (Plate 4) and the flower buds sometimes fail even to open, at others they produce badly-shaped blossoms. Galled cuttings produce weakly plants. Heavily infested stock plants become brittle and do not readily produce new growth. No galls have ever been recorded from the roots or underground stems, although various workers have mentioned searching for them (e.g. 156).

Description. Felt (118) described both sexes in detail and gave short descriptions of the gall, egg, larva and pupa. Weigel & Sanford (327) quoted these descriptions, as did also Guyton (156), while Hamilton (159) quoted the descriptions of the midges only. Weigel & Sanford (327) also gave a free translation of F. Loew's description of the male, larva, pupa and galls of *Rhopalomyia hypogaea*, the species on wild *Chrysanthemum*

* This is the official common name in America (230).

spp. which has for so long been confused with *D. chrysanthemi* of commercial chrysanthemums. It is a rather delicately built midge about 2 mm. long and the abdomen of the female is reddish orange.

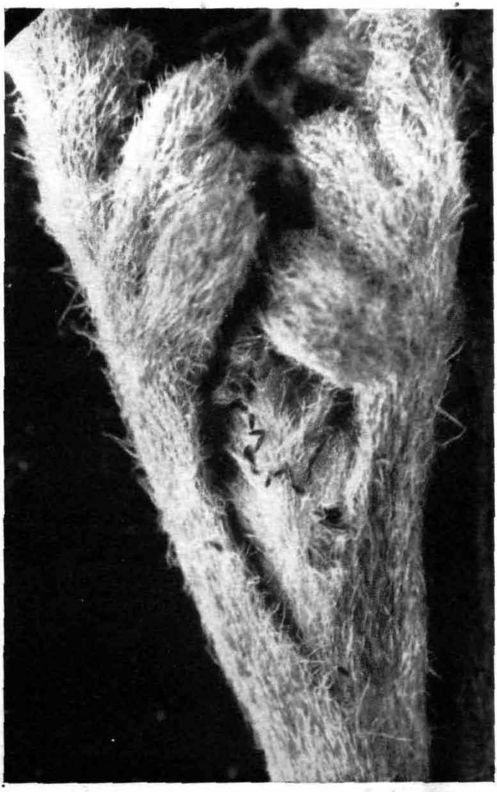
Synonymy. Felt (116) identified the Chrysanthemum Gall Midge in North America as *R. hypogaea* (F. Loew) (204). Incidentally, Felt at first stated in error that the authority of this latter species was H. Loew. This is a central and southern European species originally described from subterranean galls on *Chrysanthemum atratum* Jacq. and subsequently recorded on Ox-eye Daisy (*C. leucanthemum* L.) and *C. corymbosum* L. (201), and on *C. myconis* L. (65). Lemée (201) recorded a midge, possibly the same species, on *C. japonicum* Thunb. (= *C. indicum* L.). For further information regarding *R. hypogaea* (F. Loew), see Vol. VIII.

This identification was accepted for some years in Europe without further investigation and without experimental evidence to show that the *R. hypogaea* of wild chrysanthemum would, in fact, attack autumn commercial chrysanthemums. But then doubts arose, since the Chrysanthemum Gall Midge kept on appearing on these latter chrysanthemums in various countries with every indication that it was non-indigenous. In addition, there was no evidence of it spreading from, or to, wild species of *Chrysanthemum* in these localities. The author (28) carried out an experimental investigation into the host plant range of the midge found on autumn commercial chrysanthemums (see "Food Plants" below) and reached the conclusion that this midge should be regarded as distinct and separate from *R. hypogaea* (F. Loew) of wild *Chrysanthemum* species. Ahlberg (1) came independently to the same conclusion and proposed the present name *D. chrysanthemi* for the midge attacking autumn commercial Chrysanthemums. Unfortunately it has not yet been possible to carry out any reciprocal experiments with *R. hypogaea* (F. Loew) obtained from wild *Chrysanthemum* species. In spite of this, it seems best to consider the gall midge of autumn commercial chrysanthemum as a distinct species.

Historical. The author (28) gave a full account of this midge's occurrences on autumn commercial chrysanthemums.

It first appeared in the United States of America. The first record is that of Felt (116) who recorded it as doing serious damage to commercial glasshouse chrysanthemums during March, 1915, in Michigan. But, according to Essig (95), it had been known to Californian florists for over 15 years. Felt (118) recorded its occurrence in the same year in Oregon and also reported receiving specimens collected at Ottawa in Canada from Gibson (149), who came to the conclusion it had been recently introduced with plants from the U.S.A. In 1915 also it was found at Victoria, B.C. (150, 308). By 1920 it had been reported from all the larger chrysanthemum-growing regions of the U.S.A. (327) and by 1922 was well-established throughout the province of Ontario and had also been found in Quebec and Nova Scotia (151). It was reported as occurring in Winnipeg during September, 1942 (8).

With the possible exception of Russia, this midge first appeared in Europe during 1927 in England. A second outbreak occurred in England in 1936 and subsequently it spread to South Wales. In both instances the midges were traced to chrysanthemum varieties imported from the U.S.A. The second European outbreak was in 1934 in Denmark (42, 43). In 1936 it was reported in Sweden, although it had been seen by growers in 1935 (7). It was considered probable that it had been imported from Denmark. In 1936 it appeared in Finland and in one case it was evidently imported from Germany and in another from Sweden (*fide* N. A. Vappula and Y. Hukkinen, *in litt.*). In 1937 an outbreak occurred in Northern Ireland, and in this case it was traced to an infested area in England. In December, 1939, the Chrysanthemum Gall Midge was found for the first time in Scotland, being reported from a Lanarkshire nursery and surrounding greenhouses and gardens (40). This species is known also to attack cultivated chrysanthemums in Germany, although according to H. Sachtleben (*in litt.* 8.10.38) its occurrence had been slight and only local up to 1938. Suire (288) gave *R. hypogaea* in his list of insects attacking chrysanthemums in France, but no definite records have been found regarding the midge on commercial chrysanthemums in that country. In Switzerland, Häfliger (340) stated



Eggs of Chrysanthemum Gall Midge on Young Shoot. (*Photograph by A. S. Buckhurst*)

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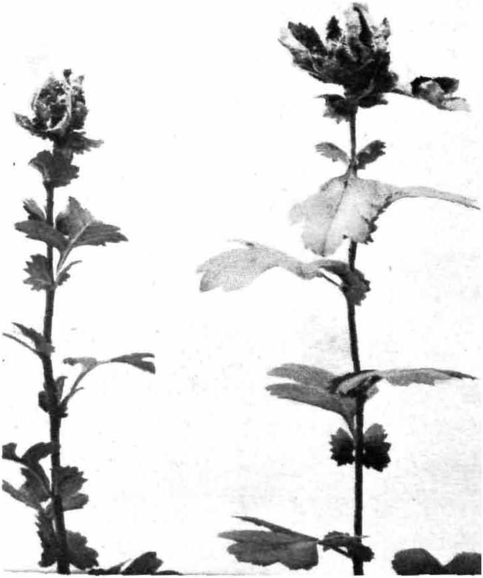
PLATE 6.



The Terminal Galls of the Hawthorn Button Top Midge, *Dasyneura crataeg*
(Photograph by F. C. Brown.)

it was first found as a pest during 1944 and was present again in 1945.

Distribution. United States of America, Canada, England, Northern Ireland, Scotland, Denmark, Sweden, Finland, Germany, Switzerland, the Channel Islands and possibly France. It is considered that it is no longer present in Northern Ireland as attempts to eradicate it seem to have been successful (Chamberlain, *in litt.*). In England, on the other hand, during the war years its distribution has increased and this pest is probably now widely established, although prior to 1939 the midge was little known outside the Worthing area.

Life History. The bionomics of this midge have been thoroughly studied in the U.S.A., notably by Guyton (156) in Ohio, Hamilton (159) in Maryland, and by Weigel & Sanford (327). In England the author (29) has made a detailed study.

While primarily a glasshouse pest, this midge also survives out-of-doors. It has been noted that this midge can persist out-of-doors during the winter in England, Canada, the U.S.A. and in the Scandinavian countries. It breeds continuously throughout the year and there are several (6–8) overlapping generations per annum. Owing to this latter fact freshly emerged midges can be found almost any day of the year in England at least. The complete development of the larva and pupa takes place in the gall which is closed.

The midges emerge in the morning. Hamilton gave the time as between midnight and 4–5 a.m. The author noted that the males had regularly emerged by 9 a.m., in fact in the laboratory all the males were either dead or dying by this hour. The females had also mostly emerged in the laboratory by this time, but a few were observed emerging as late as 11 a.m. In the glasshouse few emergences were seen during the summer after 9 a.m., but in the winter the proportion emerging later was considerably higher. Emergence is completed earlier on bright mornings than on dull ones. The actual times of emergence seems to bear some direct relationship to the time of sunrise, i.e. light may be an important factor. More midges emerged on sunny mornings than on dull ones, irrespective of

the actual temperature. But temperature does also affect the rapidity of emergence and the number of midges emerging during any one night. The threshold temperature for emergence, however, is low, since a few emergences were found to be taking place in December even when frost was on the plants and the air temperature well below freezing.

The midges themselves are short lived. Weigel & Sanford found that males usually lived less than 12 hours, while the females lived for 2–3 days in captivity when not mated. They stated that the fertilized female probably does not survive longer than 24 hours. The author gave less than 6 hours as the usual life span of the males and stated that mated females usually died the same day as they emerged, but that exceptionally they had been seen alive up to 5 days after emergence. He agreed that the usual duration of life of unmated females in captivity was 2–3 days.

The sex ratio at emergence varies, but usually there is a preponderance of females. Weigel & Sanford recorded 365 males to 464 females from a large number of cages. This gives a ratio of 44 : 56. Hamilton in one experiment on 15 plants emerged 86 males and 387 females (18 : 82). The author found the most common ratio was apparently about 36 : 64, but in families derived from isolated females, which produced 40 to 100 offspring, the sex ratio varied from 20 : 80 to 84 : 16. The following may be given from the author's data as an example of mass sex ratio. From one plant on which 5 females were allowed to oviposit in late March and early April, 1938, 6,335 midges had emerged by the end of August 1939. Of these, 2,554 were males and 3,781 were females, giving a ratio of 40 : 60.

Mating takes place almost immediately after emergence and is completed in a few seconds. Weigel & Sanford observed one female *in coitu* for 10 seconds only, approximately 3 minutes after emergence. In the laboratory many females emerged too late in the day to be fertilized, since all the males had died. In such cases they sometimes were fertilized the next morning, providing the number of newly emerged females was not too great. There was a definite preference on the part of the male

to mate with freshly emerged females. The threshold temperature for mating appears to be slightly higher than that for emergence, since on some days, although emergence took place, mating did not.

Oviposition starts soon after mating and in bright warm weather is usually completed by noon on the day of emergence. (Dustan (93) stated that oviposition was largely completed by 8 a.m.) In dull cool weather it persists much longer; on such days in the summer it may go on all day in the glasshouse or even be extended to the third day under laboratory conditions. Even in the winter in the glasshouse it may last until the third day. The threshold temperature for oviposition seems to be almost the same as that for mating, oviposition nearly always taking place as soon as fertilization had occurred. Weigel & Sanford give a detailed account of the actual process of oviposition. Hamilton stated that if a female is disturbed while egg-laying it usually flies a short distance and then returns to the same plant, while Weigel & Sanford made the same observation and further stated that the females normally oviposit on the plants from which they have emerged. The author found that mated females would oviposit in glass tubes, on muslin and in the soil when no plant material was available.

The eggs are bright red or reddish orange. They are tucked away in among the buds (Plate 5), the folds of the young leaves and the sepals of the flower buds. Occasionally they are laid on the green stems. New growth is always attractive, whether it be the terminal growth on the stems, at the axils of the leaves, on the crown or stool, or on developing flower buds.

It was noticed that during the summer midges had a tendency to fly upwards and congregate at the tops of the cages. In the autumn and winter the tendency, particularly that of the females, was reversed: they assembled at the base of the cages. This change-over may be explained by the seasonal position of the actively growing portions of the plant. When mating is over and in the case of females oviposition as well, the tendency is to fly towards the source of light.

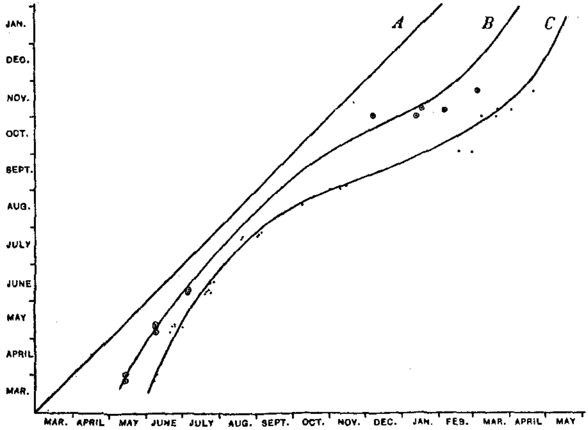
A single female lays 5–135 eggs with an average of 32 according to Weigel & Sanford, while Guyton found that the

number usually laid was from 8 to 150. The maximum number of offspring the author has reared from a single female is 100.

The incubation periods in days of the eggs is given by Weigel & Sanford as 3–16, Hamilton 4–12, Gibson & Ross (151) 2–4 and the author 3–14. It depends on the temperature and humidity and varies with the season of the year. In hot dry weather the percentage hatch is low compared with that during moist warm periods.

The larvae bore into the plant tissue and become completely enclosed within 24 hours of hatching. There is a short period when the newly hatched larvae wander about on the surface of the plant. The actual time required for a larva to enter the leaf is about half an hour. The first signs of the presence of larvae are lighter patches on the leaves. Hamilton found that the minimum time required for this sign of the galls was 7 days, while Weigel & Sanford gave the period before the characteristic white spots or swellings were visible to the expert as 4–14 days with an average of 7. Later the typical conical galls appear. The author found that the time, necessary to lapse before definite galls were readily visible to any one, varied according to the season of the year (Text-Fig. 1) from 25 days (June–July) to 102 days (November–March). In July this period may be reduced to 16 days. (In the laboratory galls were easily visible during June after 13 days.) In the winter this pre-gall period is sometimes greatly lengthened. Galls take longer to appear from eggs laid in the autumn on the slow growing basal shoots than from eggs laid on the rapidly growing later secondary flowering shoots. During the winter the galls will suddenly appear and rapidly become full sized, giving the illusion that the breeding rate is more rapid than it really is.

Text-Fig. 1 shows the dates on which galls and midges may be expected from midges laying eggs at any time in the year in an unheated glasshouse. The line A represents the dates of egg laying, B those of the appearance of galls and C the dates on which the first midges resulting from the egg laying on the line A may be expected. These curves are based on the results obtained by the author in 1938 and were closely approximated by the results obtained in the following year.



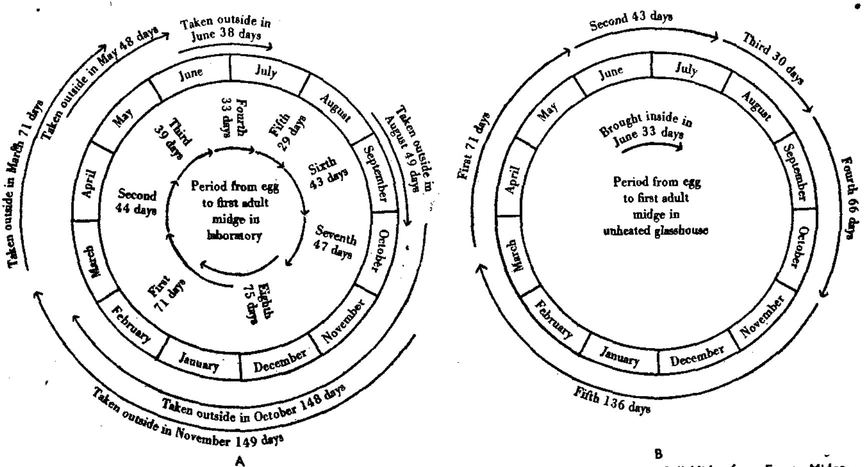
Text-Fig. 1.—Curves showing the Expected Dates of the appearance of Galls and Midges of *Diarthronomyia chrysanthemi* under Unheated Glasshouse Conditions.

The duration of the larval stage varies likewise from 2 weeks to several months. In the U.S.A. and Canada during the hot summer months and the cold winter ones development is retarded. Hamilton states that in green, healthy but dormant plants both the larval and pupal stages can survive such conditions, but that probably only the pupal stage can survive in dead plants. The larva in the gall is at first milky white but later when full grown and storing fat ready for transformation it becomes a reddish orange colour.

Usually pupation occurs about 3–4 weeks after the larva has hatched. The duration of this stage varies from 7 to 8 days to 3 to 4 months according to Hamilton, but the author found this period varied from 6 to 7 days to several weeks not months.

In England generation follows generation, in the author's experience, continuously throughout the year, gaining speed as the warm weather comes and losing it again as the winter approaches. No ceiling temperature or upper limit for breeding was found during the summer and in the winter months although the rate was greatly reduced no real hibernation was evident. Under unheated but shaded glasshouse conditions there were five generations in the course of a year (1938). Starting in March the average times from egg to first midge were: first generation 71 days (66 days in 1939), second 43 (42 in 1939), third 30, fourth 66 and fifth 137 days. In the laboratory there were eight generations in just over twelve months. Starting in January the equivalent periods were: first generation 77 days, second 44, third 39, fourth 34, fifth 29, sixth 43, seventh 47, and eighth 83. The shortest times for a completed life cycle were 26 days in the glasshouse and 25 in the laboratory. The equivalent longest times were 149 and 86 days, the latter in the laboratory being naturally shorter than that in the unheated glasshouse.

Text-Fig. 2 illustrates the time taken to develop from the egg to the first midge both in the laboratory and when taken outside from the laboratory to an unheated glasshouse and also in an unheated glasshouse and when brought inside from the glasshouse into the laboratory. It shows clearly the change



Text-Fig. 2.—Schematic Representation of the Speed in Days of Development of the *Chrysanthemum* Gall Midge from Egg to Midge. A, in laboratory and when taken outside to unheated glasshouse; B, in unheated glasshouse and when brought inside to laboratory

in speed of development under these two sets of conditions and also the effect of moving plants with eggs on them both to the greenhouse from the laboratory and vice versa.

In the U.S.A. there are also about 6–8 generations, but there seem to be two seasons of the year, the summer and the winter, when the rate of breeding is slowed down. In fact, American workers refer to aestivation (June to August in Maryland, Virginia and the District of Columbia) and hibernation periods. Weigel & Sanford observed three distinct generations in the springs of 1917, 1918 and 1919. The first generation started about the middle of February and the last midges emerged during the last few days of April. The second generation started about the middle of March, the last midges emerging about April 30. The third generation midges emerged in the early part of June. Again in the autumn there were three generations, one starting during the latter part of August and its last midges appearing during early October. A second autumn generation started in mid-September and its last midges appeared early in November. The third autumn generation began in mid-October and the last midges of this emerged towards the end of November. Hamilton also reared three spring generations from March to the middle of June and observed another generation in January and February, a summer generation and three distinct autumn ones. This worker found the life cycle was completed in 29–65 days in the spring generations, while Weigel & Sanford dealing with both the spring and autumn generations found the time required was 27–52 days with an average of 35.

In Canada Dustan (93) stated that reproduction goes on throughout the year but apparently at a much slower rate in June, July and August, probably owing to the unfavourable condition of the food plant.

Incidence of Infestation. In the U.S.A. the infestation increases from the late winter to the early summer, dies down in July and August and increases again from September to November or early December. Thus the greatest damage occurs at the time of taking cuttings and again when the plants are brought in for flowering. In England the greatest infestation

is always most noticeable in the autumn when the plants are brought indoors.

Food Plants. Autumn commercial chrysanthemums.

The author (28) made a study of the host plant range of this species and found it would breed successfully in addition on *C. indicum* L., *C. rubellum* Sealy (*erubescens* Hort.), *C. indicum* L. var. *azaleoides* (*azaleanum* Hort.) and *Chrysanthemum* Korean Apollo.

In these experiments small pustules and corrugations on the stems, in both of which young larvae were found, developed on *C. parthenium* Bernh. following oviposition. But no midges developed.

Oviposition only, without any further development, was obtained on *C. leucanthemum* L. (Ox-eye or Dog Daisy), *C. cinerariaefolium* Vis., *C. coccineum* Willd. (*roseum* Adam.), *C. maximum* Raymond (Shasta Daisy), *C. uliginosa* Pers., *C. coronarium* L. and on *C. frutescens* Thunb. (Marguerite).

No oviposition was observed on *C. zawadskii* Herbich.

Plants belonging to other genera were also tested as possible food plants. Oviposition, but no subsequent development, took place on *Matricaria inodora* (Corn Feverfew), *Anthemis nobilis* (Common Chamomile), *Anthemis cotula* (Stinking Mayweed or Chamomile), *Achillea millefolium* (Yarrow) and *Senecio vulgaris* (Groundsel). No oviposition was obtained on *Fragaria* sp. (Strawberry), *Ranuculus repens* (Creeping Buttercup), *Plantago lanceolata* (Ribwort Plantain), *Cheiranthus* sp. (Wallflower) and *Artemisia* sp.*

Weigel & Sanford (327) in America made several attempts to infest Shasta Daisy and *C. leucanthemum* but were unable to obtain oviposition on these plants. Similarly Hamilton (159) could get no oviposition on these plants but was able to secure an infestation on annual or summer varieties of *Chrysanthemum* (mixed seed and probably *C. coronarium*). The leaves were curled and twisted while the stems and buds were deformed, but no definite galls developed neither did any midges. This infesta-

* A species of *Diarthronomyia* was found breeding on this plant in Essex by D. C. Thomas. This species, when given an opportunity, oviposited on September White variety of commercial Chrysanthemum, but no further development took place.

tion' apparently resembled that obtained by the author on *C. parthenium.*

SUSCEPTIBILITY OF COMMERCIAL VARIETIES. Most varieties are liable to be attacked to a greater or less extent. No immune variety has yet been found. This is rather to be expected as most commercial varieties have been derived from *C. indicum.*

Among the varieties which have been found heavily attacked in the U.S.A. are all Chadwick varieties, Dr. Enguehardt, Elberon, Golden Mensa, Major Bonnaffon and Wm. Turner (327) and Armorita, Chadwick, Chieftain, Major Bonnaffon, Marigold, Maud Dean, McNiece, Miss Isabelle, Mistletoe, Mrs. Buckingham, Mrs. Cunningham, Mrs. Wilcox, Pink Perfection, Timothy Eaton, Unaka, Western Beauty and Whithier (159). In Canada the following varieties were most freely attacked (150): in Ontario, Aesthetic, Anna, Chrysolora, December Gem, Dr. Enguehardt, Early Snow, Elberon, Etherington, Hortus Tolsoms, Madam G. Rivol, Mrs. Clay Frick, Naomah, Pacific Supreme, Radoelii, Ramapo and Ursula Griswold; and in Victoria, Smith's Advance, Ivory, Bonnaffon, Wm. Turner, Western King, Englehart, Polepheum, Chrysolora, Mrs. Thompsom and Halliday, of which the first six were practically ruined. In addition, in Ontario, Bonnaffon (completely destroyed), Bronze Brighthurst, Celtic, La Africana, Mrs. Godfrey, Pink Star and White Chieftain were attacked (151).

In England, Cheshunt White, Everlasting, Mrs. Barrel and Monument (279) in Hertfordshire and Essex and Baldock's Crimson, Golden Butterfly, J. J. Morrish and Madame B. Latour in Lancashire (222) were the varieties most heavily attacked during the 1927–8 outbreaks.

The varieties which seemed to be least attacked in the U.S.A. are Golden Age, Harvard and White Bonnaffon (327) and Appleton, Charles Rager, Chrysolora, Early Frost, Golden Glory, Halliday, Helen Frick, C. W. Johnson, and especially Oconto, Pink Diana and Richmond, on the second of which no infestation had been noticed although eggs had been found on it in abundance (159). In Ontario, the varieties Bob Pulling,

Daily Mail, E. T. Quittington, F. T. Quilleton, Gertrude Peers, Mrs. G. C. Kelly, Oconto and W. Wood Mason were fairly free from injury (150). In England, Baldock's Bronze, December Gold, Franfield Orange, Gloriosa, Mrs. A. Cross, Pantia Ralli, Pink Pearl, Queen of the Pinks and Uxbridge Pink were less infested than the varieties cited in the preceding paragraph (222).

The above statements are all based on observations of infestations in commercial glasshouses. It is highly desirable that experimental evidence is obtained in order to establish whether or not there is any real difference in varietal susceptibility to attack.

Natural Enemies: Predators. In the U.S.A. two flies, *Platypalpus aequalis* Loew and *Tachydromia rostrata* Loew, have been observed sucking the juices out of the midges. But they were not numerous enough to exert much control (159).

Two ants, *Aphaenogaster fulga* Rojer sub. sp. *aquia* Bucky and *Tetramorium caespitum* L., have been recorded by the same investigator as opening the galls and feeding on the larvae or pupae and even emerging midges. It appeared that in June and July at least 50 per cent. of the galls had been destroyed by these ants, but in February to March the percentage opened by the ants varied from 4 to nearly 20 per cent., averaging nearly 11. Hamilton came to the conclusion that they helped appreciably in checking the summer increase of the midge.

In England the equivalent predator to the ants was found to be the common earwig (29). The latter insect leaves merely holes in the leaves where the galls have been, whereas, in the case of the ants the ends of the galls are eaten and the midge is extracted. The earwig, however, cannot be considered beneficial owing to its habit of damaging the chrysanthemums themselves. In addition to the earwig, a large red velvety mite was observed preying on the midges' eggs and occasionally on emerging female midges, while a Pentatomid and an Anthocorid bug were also found sucking the eggs and ovipositing female midges.

Natural Enemies: Parasites. Essig (95) reared two Chalcid parasites, *Amblymerus* sp. and *Tetrastichus* sp., from the galls.

In a few cases as many as 80 to 90 per cent. of the midges were destroyed in the summer months.

Hamilton (159) reported the Chalcid *Tetrastichus diarthronomyiae* Gahan (144). This species has a longer life cycle than the midge. Hamilton gave notes of the bionomics of this parasite and stated that it was only found resting on yellow bloom. None was to be found on other coloured blossoms. The parasite was present in five out of nine glasshouses examined and the parasitism averaged 19 per cent., although it ranged up to 54 per cent.

In England *Eutelus diffinis* Walker was bred out of the galls (28).

CONTROL MEASURES. For original or detailed accounts of control experiments reference should be made to the papers of Essig (95), Gibson (149), Felt (118), Guyton (155, 156), Weigel & Sanford (327), Wallace & others (319, 320), Hamilton (159), Barnes (29) and Dustan (93).

It has been abundantly proved that the midges can be killed while they are emerging by fumigation with hydrocyanic acid gas or by nicotine fumes. The dosages recommended by Weigel & Sanford are one-eighth to one-fourth of an ounce for each 1,000 cubic feet of space if hydrocyanic acid gas is used or one sheet of nicotine paper to every 1,000 cubic feet. Such fumigation, however, does not kill the larvae in the galls (see p. 61). Dustan mentioned that the fumigant methyl bromide was the only insecticide that has been shown, up to the time of his experiments with lauryl thiocyanate, to be a spray that kills appreciable numbers of larvae within the galls (see p. 61). The author is not aware of any paper describing the use of methyl bromide against this midge.

The disadvantages of fumigation are that the fumigation must be done at night when the midges are emerging and it must be repeated nightly owing to the prolonged emergence period; the dangerous character of hydrocyanic acid gas, necessitating a competent fumigator; and the fact that all glasshouses are not suitable for fumigation by reason of their construction preventing one block being isolated from the others. Owing to such reasons as these, fumigation has been adopted by large

growers of chrysanthemums in the U.S.A. but not by the smaller growers or those growing a variety of crops.

Spraying has also been proved to be effective against the emerging midges and the eggs. A suitable formula consists of nicotine 95–98 per cent. at a strength of 1 part to 800 parts of water, i.e. 2 oz. per 10 gals., with a sufficient quantity of soft soap (1 lb. to 10 gals.) or other spreader. Alternatively, the use of 40 per cent. nicotine sulphate or free nicotine with the addition of a casein-lime spreader (Hamilton gives the rate as one rounding tablespoon to each 2 gals. of solution) or a non-caustic soap (1 oz. to each 1 or 2 gals. of solution) has been stated to give good results. If the water is known to be very hard the use of sulphonated lorol might be substituted with advantage. The recommended strength of such a spray has varied; Essig gave 1 part nicotine sulphate in 1,600 parts of water; Weigel & Sanford 1 part in 800, while Guyton and Hamilton both gave 1 part in 500.

Fair results have been obtained by using a proprietary extract of pyrethrum, 1 to 500 of water, with the addition of 1 oz. of soft soap to each 2 gals. The infested plants so sprayed were slightly taller and had greener foliage than those sprayed with nicotine. But Hamilton stated that further knowledge was required before substituting pyrethrum for nicotine in spraying.

Recently Dustan (93) experimented with certain proprietary sprays containing thiocyanates with marked success. His results showed that 1–4 applications at 3- to 4-day intervals of a spray containing lauryl thiocyanate as the active ingredient was more effective than sprays, applied a similar number of times, containing either nicotine sulphate, free nicotine, normal butyl carbitol thiocyanate, rotenone-bearing insecticides or white oil. In addition, and this is a definite step forward in the control of this midge, lauryl thiocyanate was the only substance tested which killed most of the larvae in the galls. This material, diluted 1–600 and 1–400 was 100 per cent. effective as an ovicide, while the other materials tested gave lower kills. Under cage conditions 4 applications of the lauryl thiocyanate spray 1–400 usually gave complete control when all parts of the plants were covered with the spray. Incomplete control resulted

from incomplete coverage, reducing the number of applications and increasing the dilution, e.g. to 1–800. Large-scale trials with plants on open benches showed that 4 applications at 1–400 followed by 4 applications at 1–600 at weekly intervals did not quite achieve complete control. A commercial grower repeating these tests obtained the same results. Incomplete plant coverage was assumed to be the cause of the failure to obtain complete control under these conditions. Dustan therefore recommended 3–4 additional weekly sprayings at 1–600 with special care taken to use more spray and to hit both sides of the leaves. He also suggested that the best time to apply lauryl thiocyanate was in the winter after the chrysanthemums have been cut back and before cuttings are taken. There would be less foliage to cover at this season of the year and the plants would soon grow away from any slight injury which might result from the insecticide.

The disadvantages of spraying are that it should be repeated about every fourth day, it should be done late in the afternoon for the best results, it is very difficult to reach all the foliage when the plants are large and, even if it is reached, to obtain a good wetting, and that growth may be retarded by the use of nicotine.

An alternative method of killing the eggs is to dip infested cuttings in a solution of the spray material before planting. Here again a retardation of growth has been observed when nicotine is used. Dustan tested the use of the lauryl thiocyanate spray as a dip for cuttings. In a small-scale experiment he found that at a dilution of 1–800 with no additional spreader almost a complete kill was obtained.

The complete procedure for controlling the midge is based on chemical and cultural practices, all of which must be scrupulously carried out to ensure success. If this is done for two or three seasons there is fair chance of exterminating the midge:

1. All plants not required for propagating should be destroyed immediately after flowering. It is preferable to assemble the stock plants in one house if possible.

2. Regular twice-a-week spraying of these plants should be started four or five weeks before it is expected to commence

taking cuttings. While spraying it should be remembered to attempt to reach and wet both surfaces of the leaves.

3. Before starting the spraying all the tips of the new growth should be removed and destroyed. Later, all above ground growth can be cut away with advantage.

4. Cuttings should only be taken from subsequent new growth. While this is appearing the spraying should be continued as before.

5. All cuttings should be dipped and thoroughly wetted in the spray solution before planting.

6. They should be removed immediately for rooting into a glasshouse or frame in which there have not been any chrysanthemums for at least 14 days.

7. As soon as the required cuttings have been taken, the old stools should be destroyed. Care should be taken to destroy all plant remains, especially the leaves which are liable to be blown away into odd corners and overlooked. The destruction by fire of large quantities of stools is often difficult, but burying them at a depth of at least 1–1½ feet has been recommended as an alternative. Care should be taken to consolidate the soil on top of such stools.

8. It is inadvisable to spray the cuttings as this is liable to cause damage. Following an old Californian practice, covering the cuttings and young plants with cloth might be advantageous in preventing a fresh infestation.

In the summer before the plants are placed indoors spraying can be carried out twice a week for a period of 4 to 8 weeks. There are, however, many difficulties attendant on such a practice and it should not be attempted unless the infestation is so severe as to be likely to affect the sales of the blooms or spread the midges to neighbouring growers. Among the difficulties may be mentioned the slender chances of obtaining suitable days for spraying, the time at this busy season of the year and the cost.

Since it is exceedingly difficult to ensure that every grower with infested stocks will carry out the above procedure adequately, preventive measures should be taken to prevent new infestations. For this purpose inspection of material for export

and import is invaluable. Any new cuttings brought into a nursery should be dipped, isolated and grown under cloth temporarily until there is no further chance of galls becoming visible. If any infestation on newly purchased material is discovered, it would always pay to burn the whole consignment or refuse delivery. Growers might with advantage refuse to buy from infested nurseries and make it widely known why they refuse to buy.

Finally, Pyenson's experiments (342) on the control of the Box Leaf Mining Midge (see p. 41) by D.D.T. suggest that this insecticide may prove to be efficacious against the Chrysanthemum Gall Midge.

Closely Allied Species. *Rhopalomyia hypogaea* (F. Loew), and probably several other species such as the English *Diarthronomyia* species on *Artemisia* previously mentioned (p. 57) and the American *D. californica* Felt from *Artemisia californica* and *D. artemisiae* Felt from *A. tridentata.*

Material. Males, females and pupae, England and Finland. Larvae, England.

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CLEMATIS (*Clematis* Dill. ex L.)

No gall midges have been reported as pests of Clematis although several species have been recorded from this genus of plant and may well appear as pests in the future.

Thus, in America *Asphondylia clematidis* Felt, of which the male and female were originally described (134), causes the so-called "Clematis bud gall" in Texas, U.S.A., on *C. drumondii* T. & G. or Grandaddy Gray Beard. They are subglobular bud galls each containing a single larva. The outer surface is woolly and the gall usually appears on the buds at the axils of the leaves and branches (232). The midges were reared in August and are heavily parasitized. The midge, *Contarinia clematidis* Felt, first mentioned very briefly in a key by Felt (103), also causes a subglobular gall in the leaf axils. Later the male was described in more detail (122). The term "Clematis bud gall" was also applied to the gall made by this species (121). *Contarinia clematidis* was found in New York State on *Clematis virginiana* or Virgin's Bower. *Dasyneura clematidis* Felt was also first named in a key by Felt (103) and later descriptions of both sexes were given (111). This species was also reared from an irregular subglobular gall on *C. virginiana* in New York State. *Neolasioptera clematidis* Felt was likewise first mentioned in a key (103) and later (120) a detailed description of the female was given. The female was observed while attempting to oviposit in a slit in the stem of *Clematis* in New York State. The gall is stated by Felt (136) to be reddish-brown and axillary, of $\frac{1}{6}$-in. diameter compared with $\frac{1}{8}$-in. diameter galls which are produced by *A. clematidis*. There is also the Clematis Flower Midge, *Prodiplosis floricola* (Felt). This species was originally briefly described on a male reared from enlarged reddened flowers of the Meadowsweet, *Spiraea salicifolia*, in New York State (101). Later the same species was apparently reared from enlarged blossoms of *C. virginiana* in New York State. A more detailed description of the male and the gall were also given (125). Lastly, in the U.S.A., there is *Lestodiplosis clematiflorae* Felt (103), a predaceous form which was reared from unopened but otherwise apparently normal flowers of *Clematis* (121).

In Europe only one named gall midge is known to occur on Clematis. This is *Dasyneura? clematidis* (Kieffer), which was reported by Frauenfeld (139) in central Europe as living in the unopened and swollen flowers of *Clematis viticella* L. Kieffer

(194) merely gave this name to the gall, referring to Frauenfeld's record. The name is invalid since Felt had used this name a year earlier for an American species of gall midge (see p. 65). But it is obviously not much use to give a new name to Frauenfeld's gall, but rather to wait until such time as the midge is rediscovered and described. Massalongo (216) also reported the larvae of what would now be considered a *Dasyneura* species causing a terminal hairy leaf gall on *C. recta* L. in Italy. Lastly, Trotter (311) reported from Italy gregarious white larvae of an unidentified Cecidomyid being present in a stem of *C. flammula* L., thickened at the point of bifurcation of the branches.

COSMOS (*Cosmos* Cav.)

There are in the author's collection larvae of a *Clinodiplosis* species (see p. 9). These were found among Cosmos seed by G. Fox Wilson, of the Royal Horticultural Society's Laboratories, Wisley, Ripley, Surrey, during November, 1931.

DAHLIA (*Dahlia* Cav.)

Apparently the only midge that has been recorded from Dahlia is *Clinodiplosis dahliae* Kieffer. Both sexes and the pupa were described (192) from material reared by Kieffer from larvae sent him from Vallombrosa, Italy, by Cecconi. The red larvae were found living during the autumn in the flowers of *Dahlia* species. The flowers remained more or less atrophied and finally rotted. It is distinctly unusual for *Clinodiplosis* gall midge larvae to be responsible for actual plant damage (see Preface, p. 10). The larvae left the flowers and descended to the ground at the beginning of October. Emergence of the midges took place the following year in September and October.

DAPHNE (*Daphne* Tourn. ex L.)

Only a single reference to gall midges on Daphne has appeared in economic literature. Maskew (214) reported intercepting a *Cecidomyia* species on Daphne sent from Japan to the U.S.A.

However, in Europe two species have been recorded from various species. *Dasyneura daphnes* (Kieffer) was described (189) on the male only. The white larvae are gregarious and live in malformed terminal shoots of *Daphne cneorum* L. The internodal spaces are foreshortened and the leaves clustered forming a globular or oval mass. The larvae when full grown descend to the soil, the midges emerging towards the middle of June the following year. Kieffer found this species near Bitsch in Lorraine and Dalla Torre (69) recorded it from central Europe. Kieffer (189) also found a similar malformation on *D. mezereum* L. as did also Dalla Torre (71) and Thomas (303) in central Europe, Miss Dombrowski (91) in western European Russia and Massalongo (217) in Italy. Thomas (303) also found the gall and larvae of what may be the same species on *D. striata* Tratt. in central Europe and Corti (58) did likewise in Italy; while Houard (169) described the same gall on *D. laureola* L. in France.

The second species is *Dasyneura daphnephila* (Kieffer) (194) of which only the gall and larvae are known. The perianth is changed into a sphere 3–5 mm. in diameter, while the ovary is hypertrophied and the stamens are swollen. Inside are to be found white gregarious larvae. Thomas (301, 303) found this gall on *D. striata* Tratt. in central Europe.

FALSE SOLOMON'S SEAL (*Maianthemum canadense* Desf.)

Dasyneura torontoensis Felt (117) was described on females only. A short description of the larva was appended. The gall is an elongated swelling about 8–12 mm. long with a diameter of about 2–3 mm. on the root and contains a single whitish larva. It was found in the spring of 1915 by J. H. Faull of Toronto University. Four females were reared by A. Cosens late in June, who never saw them make any attempt to fly and thought that their light colour indicated that the greater part of their existence was spent underground (64).

Felt (121) also recorded an undescribed *Cecidomyia* species causing a leaf blister gall on this plant.

GENTIAN (*Gentiana* Tourn. ex L.)

Larvae of a *Clinodiplosis* species (see p. 9) were found among seeds of *G. asclepiadea* received from Kew, Surrey, by G. Fox Wilson in November, 1943. The author bred one female midge which emerged on May 29, 1944. Larvae and the female are in his collection.

Bagnall & Harrison (10) recorded *Dasyneura? gentianae* (Kieffer) from Northumberland and Durham in the flowers and seed-cases of *G. campestris* and *G. amarella*. They pointed out that the examples found in the seed-cases might be referable to a second species. The name *gentianae* was first given to the gall by Kieffer (194). Apparently the midge has not been seen or described. Trail (307) originally found this gall, and subsequent references to it by Kieffer (185, 191) merely refer to Trail and mention that the flowers of *G. campestris* are swollen and remain closed. Trail himself stated that he found in Braemar during August, 1882, two plants with the flowers containing pale yellow larvae of a *Cecidomyia*. Some of the flowers were abnormal in having buds growing in the axils of the petals and from the centre of the ovary, while others were only slightly swollen and fleshy. The larvae were numerous inside the ovaries and the seeds were then destroyed. In other cases the larvae were present in small numbers between the other parts of the flowers. Trail stated that Dr. Dickie had described (*Edin. Bot. Soc. Trans.*, **2**, 192–6) similar abnormal flower buds from near Aberdeen.

GLADIOLUS (*Gladiolus* (Tourn.) L.)

Clinodiplosis larvae have been found in two positions on Gladiolus, namely in the leaf sheaths and among the seed. Thus larvae found in the leaf sheaths of Gladiolus at Harpenden during October, 1931, were received from W. C. Moore of the Ministry of Agriculture and Fisheries Plant Pathological Laboratory. Midges emerged from this material in an outside unheated insectary from May 31 until June 30, 1932. They have not yet been mounted and incorporated in the Barnes collection. The females have carroty-coloured abdomens,

while the males are lighter. In both sexes the thorax is pale sulphur. Moore stated that the shoot in which the larvae were found was dead, while the other on the plant was still green, healthy and had flowered.

Larvae found among the seed of Gladiolus at West Ewell, Surrey were submitted to the author by G. Fox Wilson during November, 1933. Similar larvae found by the author at Harpenden, Hertfordshire, at the end of September, 1936. Midges from the latter emerged in an outside unheated insectary from May 20 until September 17, 1937. During May and June the midges emerged regularly but in addition three emerged in July, two in August and seven in September. They emerged between 7 and 7.30 p.m. (G.M.T.) in the evening. Specimens of this midge have not yet been mounted and incorporated in the author's collection. A *Lestodiplosis* species was also reared from this material.

In addition to these *Clinodiplosis* larvae, other larvae, probably belonging to the genus *Mycophila* (see Vol. I, pp. 61–3), were found on Gladiolus near Belfast, Northern Ireland and received from F. Laing during August, 1939. It was not stated on what part of the plant they were found.

HAWTHORN (*Crataegus* Tourn. ex L.)

Certain varieties of *Crataegus* are grown as ornamentals. In some cases the wood is used as a substitute for box wood and it is commonly allowed to grow as a hedge.

The gall midges attacking *Crataegus* are dealt with in this volume in spite of the fact that this plant serves as a reservoir for many insects which are pests of apple, pear and plum and therefore can rightly be considered an undesirable weed in the neighbourhood of orchards. Of the numerous midges reported from *Crataegus*, only three species have also been reported from other plants and in no case are these primary gall producers.

In Europe ten species of gall midges are associated with *Crataegus*. Of these, five inhabit the flowers, one lives under the bark and the remaining four attack the leaves. This is in

marked contrast to the thirteen American species of which all but one are associated with the leaves. Only one of the European species has been reported from any plant besides *Crataegus* and that is a predatory form. A synopsis of the European species is given in Table I. They have little economic significance. However, *Dasyneura crataegi* (Winnertz), the Hawthorn Button Top Midge, has frequently been reported as its galls are often so obvious and sometimes unsightly. The effect of an attack by this species is to prevent terminal growth and encourage side-shoots which are desirable when thorn is used as a hedge plant. The other species which occurs in economic literature is the Hawthorn Stem Midge, *Thomasiniana crataegi* Barnes, whose larvae cause the bark to flake, resulting in the death of the leader shoots, and closely resemble those of the Red Bud Borer (*T. oculiperda* Rübsaamen) (p. 103) and the Raspberry Cane Midge (*T. theobaldi* Barnes) (see Vol. III). Brief notes on the ten species are given below.

Contarinia anthobia (F. Loew) is a common species occurring in Sweden (317), central Europe (202), Germany (244), France (235), Portugal (295) and Great Britain (10). The

TABLE I

SYNOPSIS OF GALL MIDGES ASSOCIATED WITH *CRATAEGUS* IN EUROPE

Habitat	*Midge*	*Probable Rôle of Larvae*
Flowers:		
Unopened blossom	*Contarinia anthobia* (F. Loew)	Gall producer
" "	*Dasyneura fusca* Rübsaamen	Inquiline?
" "	*D. oxyacanthae* Rübsaamen	Gall producer
" "	*D. oyensis* (Tavares)	" "
Ovary swollen	Cecidomyid	" "
Leaf:		
Terminal rosette	*Dasyneura crataegi* (Winnertz)	" "
" "	*Phaenobremia cerasi* (H. Loew)	Predator
" "	*Prolauthia circumdata* (Winnertz)	Inquiline?
Marginal leaf roll	Cecidomyid	Gall producer
Stem:		
Flaking bark	*Thomasiniana crataegi* Barnes	" "

ivory-yellow larvae live gregariously in the unopened blossom of Hawthorn (*C. oxyacantha* L.). The larvae leave the blossom

when full grown and pass the winter in the soil, pupating the following spring shortly before the midges appear. Loew (202) described the male and female as well as the gall. An *Inostemma* species has been recorded as parasitizing this species in France (235).

Dasyneura oxyacanthae Rübsaamen is recorded from Germany and England, in the latter country Bagnall & Harrison (12) reported it and the next species as being widely distributed. The larvae are red and live in the unopened blossom of Hawthorn (*C. oxyacantha* L.). According to Bagnall & Harrison, they as well as those of *D. fusca* occur much later than the larvae of *C. anthobia.* Rübsaamen (260) described the male only and stated it has 2 + 16 segments in the antenna.

D. fusca Rübsaamen is similarly recorded from Germany and in England by the same investigators (12). The larvae are orange in colour and live with those of *D. oxyacanthae* in the unopened blossom of hawthorn. They may be inquilines. Rübsaamen (260) described the male which has 2 + 11 antennal segments and mentioned that the female is similar but that, as usual in this sex, the abdomen is more reddish yellow in colour.

D. oyensis (Tavares) has only been recorded from Spain where the larvae live in the flowers of *C. monogyna* Jacq. Tavares (296) described both sexes, pupa and larva.

An undescribed Cecidomyid has been reported by Pierre (235) in France. The larvae are white and live in the swollen ovaries of Hawthorn. They pupate in the soil.

D. crataegi (Winnertz), the Hawthorn Button Top Midge, occurs throughout Europe and in Asia Minor. Winnertz recorded it on *C. oxyacantha* L. and *C. coccinea* L. and described both sexes (338). Trotter (310) recorded it on *C. azarolus* L. in Asia Minor and Wahlgren (317) recorded it on *C. curvisepala* in Sweden. The larvae live gregariously in terminal rosettes of leaves which are often very conspicuous (Plate 6). But few details are known concerning its life history. Large numbers of reddish larvae live in the galls and pupation takes place both in the gall and in the soil. There seems to be more than one generation a year, since in 1937 midges emerged between

July 23 and September 8 from galls collected at Harpenden on July 3. Usually, however, the larvae descend to the soil for pupation and emergence takes place the following spring. For example, galls collected at Harpenden on July 25, 1929, produced midges which emerged between May 27 and June 30, 1930. Hymenopterous parasites emerged from these galls in the autumn of 1929 and again during the following June. Winnertz states the duration of the pupal stage is 14 days. Larvae, males and females from Cambridge and Hertfordshire are in the author's collection.

Prolauthia circumdata (Winnertz) apparently has not been recorded since Winnertz described both sexes (338). He stated that the yellowish-red larvae live in leaf rosettes of *C. oxyacantha* from May to August and the midges emerge after a pupal period of 2–3 weeks in the soil. It may be an inquiline of *D. crataegi.*

The third species recorded from terminal rosettes of hawthorn is *Phaenobremia cerasi* (H. Loew) (206). This species was considered by Kieffer and Rübsaamen to be identical with *P. aphidimyza* (Rondani). But its exact identity is uncertain as several species have been recorded under the latter name (26). Loew originally recorded *P. cerasi* from swollen terminal shoots of cherry. Winnertz (338) stated he had found it living among the larvae of *D. crataegi* in the terminal rosettes of *C. oxyacantha.* This investigator recorded that the larvae pupated in the soil and after 2–3 weeks emerged as midges. The larvae of *P. cerasi* are probably zoophagous and those of *P. aphidimyza* are considered to be predaceous on aphids. These species will receive further attention in the appropriate section of Vol. VIII.

The last species to be associated with the leaves of *Crataegus* has not been identified. Both Schrank (270), who called them *Tipula oxyacanthae,* and Kieffer (191) recorded red Cecidomyid larvae living gregariously in a marginal leaf roll in central Europe.

Lastly, in Europe, there is the Hawthorn Stem Midge, *Thomasiniana crataegi* Barnes (28), which is, biologically and morphologically, very similar to the Red Bud Borer (p. 103)

and the Raspberry Cane Midge (see Vol. III). Both sexes were described and the bionomics of the three species as then known were compared. The conclusion was reached that *T. oculiperda*, *T. theobaldi* and *T. crataegi* form a group of midges which are morphologically very difficult, if not impossible, to separate when one is dealing with numerous specimens. Biologically they have many common attributes, but there are differences, e.g. host plant range. Larvae, males and females, including all the cotypes, are in the author's collection. This species has been found in Shropshire, Staffordshire, Warwickshire and Hertfordshire in England and possibly in Germany (264). The pink larvae live in clusters under the bark of hawthorn. As a result the young branches are killed and become noticeable owing to the withering leaves turning brown. There seem to be two generations a year, midges being on the wing in August and September and from the end of May until mid-July. Oviposition only takes place in artificial and natural slits in the bark and not on undamaged stems. Emergence occurs from 3.30 to 7.30 p.m. (G.M.T.) and oviposition goes on in the evening from about 7 p.m. until dark (in early June). During the rest of the day the midges remain settled on the stems. Pupation takes place in the soil. The summer generation takes 56–62 days. There was a strong indication that unisexual families occur in this species just as in the case of *T. oculiperda*. This species could not be induced to oviposit on Roses or on Raspberry.

In America thirteen species of gall midges have been associated with *Crataegus*; of these all but two are restricted to Hawthorn. Of these exceptions, *Rhizomyia absobrina* (Felt) has been recorded in addition on *Populus* and *Prunus virginiana*, while *Mycodiplosis cerasifolia* Felt has also been reported from *P. virginiana*, but neither are primary gall formers. Brief notes of what little is known about the thirteen American species are given below. None of them can be considered to be of economic importance. A synopsis of the species, and their larval habitat and rôle is given in Table 2.

Rhizomyia absobrina (Felt) (101, 102) was reared in July, 1906, at Albany, N.Y., from a jar containing *Crataegus* leaves bearing

green, subcylindric, fimbriate unicellular galls. Later Felt (111) re-described the male and female and recorded that apparently the same species had been reared from a jar containing subglobular poplar leaf galls and from another filled with distorted cherries infested with *Contarinia virginianiae* (Felt) (printed *Dasyneura virginiana* Felt in error). At the same time Felt illustrated the gall in colour (Plate 3, Fig. 16 in 111) and stated that *Winnertzia hudsonici* and *R. absobrina* were both reared from this gall and that *R. absobrina* at least was probably

TABLE 2

SYNOPSIS OF GALL MIDGES ASSOCIATED WITH *CRATAEGUS* IN NORTH AMERICA

Habitat	*Midge*	*Probable Rôle of Larvae*
Fruit:		
Infested with rust	*Mycodiplosis cerasifolia* Felt	Rust feeder
Leaf:		
"Fringed-cup gall"	*Lestodiplosis crataegifolia* Felt	Predator
" "	*Rhizomyia absobrina* (Felt)	Inquiline
" "	*Winnertzia hudsonici* Felt	Decayed vegetable matter feeder
"Thorn vein gall"	*Lobopteromyia venae* Felt	Gall producer
" " "	*Dicrodiplosis venitalis* Felt	Predator
"Cocks-comb gall"	*Trishormomyia crataegifolia* (Felt)	Gall producer
"Purple leaf blotch"	*Lasioptera excavata* Felt	" "
	Rhizomyia hirta Felt	Inquiline
Marginal leaf roll	*Lestodiplosis florida* Felt	Predator
"Tufted thorn gall"	*Cecidomyia bedeguar* Walsh	Gall producer
Thickened vein fold	Cecidomyid	" "
Subglobose polythalmous vein gall	Cecidomyid	" "

an inquiline. Wellhouse (335) reared this species, as well as *Lestodiplosis crataegifolia*, from the "hawthorn fringed-cup gall" which he illustrated. This investigator stated the galls, which are cup-shaped and covered externally with round-tipped spines, occur on the larger veins and petioles of the leaves and on the ends of young twigs of *Crataegus pruinosa* and *C. macracantha*. The opening of the galls is on the upper leaf surface. He found one white larva in each gall during June.

Rhizomyia hirta Felt was reared in August, 1907, from a

reddish blister-like leaf mine on *Crataegus* collected at Bath, N.Y. Only the female was described (107). Later Felt (111) stated that the gall was presumably that of *Lasioptera excavata* and implied that *R. hirta* was an inquiline.

Winnertzia hudsonici Felt (103) was reared at the end of July, 1907, at Albany, N.Y., from a jar containing leaves of *Crataegus* bearing the same type of galls as those from which *R. absobrina* had been previously reared. Later Felt (114) gave a detailed description of the female only and stated that this species presumably came from decaying vegetable matter. Felt (121) termed the malformation as the "fringed-cup gall".

Lasioptera excavata Felt (101, 102) was reared in August, 1907, from a blister-like mine found on the leaves of *Crataegus* near Albany, N.Y. Only the female was described. Later Felt (120) gave a re-description of the female as well as a short description of the larva. One to six whitish larvae may occur in a leaf and each blister is about 8 mm. across, pale green in colour and surrounded by a broad reddish-brown area about three times the diameter of the blister itself. Felt (111) illustrated the gall in colour and (121) used the term "purple leaf blotch" to denote it.

Lobopteromyia venae Felt was reared at the end of May, 1907, from greenish pouch-like vein galls on *Crataegus* found at Nassau, N.Y. The same galls have been recorded by Miss Stebbins (281) from Massachusetts. The species was raised on a single female (110). Wellhouse (335) illustrated the gall and stated that the round or oval thick-walled green galls are to be found in June on either surface of the leaves of *C. punctata* and always include one of the larger veins. Each gall opens on the opposite side of the leaf by a narrow slit extending its entire length along the vein. This investigator follows Felt (121) in calling it the "thorn vein gall".

Dicrodiplosis venitalis Felt was reared in September, 1907, from the same type of gall as the above species and was also found at Nassau, N.Y. Only the female was described (110). Later Felt (122) stated that larvae are probably predaceous.

Mycodiplosis cerasifolia (Felt) (101, 102) (see Vol. III, p. 32) was reared by Wellhouse (334) from larvae found living on

hypertrophied fruits of *Crataegus* species at Ithaca, N.Y. The identification was made by Felt. The infested fruits were infected with the Crataegus or quince rust, *Gymnosporangium clavipes* C. & P. The midge larvae were feeding on the aeciospores. Larvae collected on August 1 left the fruit within 2 days and emergence took place on August 12. Later more larvae were found in September and early October. No larvae were found on the fruits in the winter, so they probably pass the winter in the soil. The larvae were recorded from the following species of *Crataegus: neofluvialis, punctata, macracantha, pruinosa* and *tomentosa.*

Lestodiplosis crataegifolia Felt (103) was reared in July, 1907, from an irregular rather spiny gall on the upper surface of a *Crataegus* leaf found at Bath, N.Y. This species is probably predaceous. The same authority (121) stated it was reared from the same gall as *Rhizomyia absobrina* and gave illustrations of the galls. Felt (125) described the gall and larva and re-described the male. Apparently only one specimen was reared. It has already been mentioned that Wellhouse (335) also reared it together with *R. absobrina* from the "hawthorn fringed-cup gall".

Lestodiplosis florida Felt (103) was reared at the end of June, 1880, from a marginal leaf roll found on *Crataegus* at Fort Georgia, Fla. The larvae which are probably predaceous (121) are stated by Felt (125) to have occurred near the edge of the lower side of the younger leaves causing the edge to bend down and roll up. At the same time the male and female were re-described.

Trishormomyia crataegifolia (Felt) was first reared from whitish oval cocoons adhering to *Crataegus* leaves, the larvae being taken from the "cocks-comb gall" on *Crataegus.* The male and female were described (99) and later (125) re-described with some additional information and descriptions of the gall and cocoons. This species has been recorded from Nassau, N.Y., Michigan and Ontario, Canada (179). The gall is green turning yellow, red or brown, strongly compressed, length 1 cm., height 2 cm., and with an irregular serrate edge. It has been figured by Felt (111) in colour and by Wellhouse (335). The

latter stated that the galls occur on both sides of the leaves in August and that he had found them on *C. pruinosa, C. macrosperma* and *C. coccinea.* Felt (125) recorded *Eupelmus dryorhizoxeni* Ashm. and *Torymus* species being reared from this gall.

The name *Cecidomyia bedeguar* was given by Walsh (321) to a subglobular filamentous leaf gall on *Crataegus tomentosa.* No midge, however, has yet been reared from it although Walsh reported finding orange larvae in the gall. The gall has been reported from Massachusetts by Miss Stebbins (281) and Ontario by Jarvis (178). This gall is known as the "tufted thorn gall" (121) or "burr gall" (178).

Two other galls on *Crataegus* have been attributed to gall midges in America although the midges have not been reared or named. One is subglobose, frequently pointed, greenish, polythalmous and was illustrated by Felt (121). The other is a red or green, fusiform, thickened vein-fold gall figured by Felt (121) and by Wellhouse (335), who stated that a single yellow larva was found in each gall in July and August.

HEATHER (*Erica carnea* L.)

Damage to an ornamental heather (*E. carnea* var. *atrorubra*) has been reported by a grower in Cornwall (autumn, 1946), and by another near Birmingham (May, 1947). The galls, which are illustrated on Plate 10, are terminal and each contain a solitary red larva. Apparently, this gall midge is *Wachtliella ericina* (F. Loew). Specimens of both sexes, the larva and pupa are in the author's collection. F. Loew (204) originally figured the gall and described both sexes, the larva and pupa, from material found on *E. carnea.* Pupation occurs in the galls and the midges appear in the second half of June. This species is on record from central Europe, Italy and England. In the last-named country Bagnall & Harrison (10) reported it from Durham and Yorkshire.

Hemerocallis fulva L.

F. Loew (204) reported finding gall midge larvae in the flower buds of *Hemerocallis fulva* during June and July in a garden in Vienna. The buds were swollen and remained shut.

The pale brown larvae were gregarious. They pupated in the ground and the midges emerged the following May. Later (205) Loew described both sexes as well as giving more detailed descriptions of the larva and gall. Loew had by this time found it in Seebenstein as well as in Vienna. He named this midge *Diplosis quinquenotata*. Kieffer (184) transferred it to the genus *Contarinia*. The gall is figured by Rübsaamen & Hedicke (263).

HIBISCUS (*Hibiscus* L.)

The Hibiscus Bud Midge, *Contarinia maculipennis* Felt, occurs in the Hawaiian islands. The larvae which live in unopened flower buds of Hibiscus are stated to have been first found in Hawaii about 1928 (176). The buds, when attacked, usually fall off before opening. Midges were not reared until 1929 when Swezey (289) reported breeding them from the buds of a dark pink variety having a dark red centre grown on the island of Kauai. In this case the larvae were full grown in late September. In a later occurrence on Oahu during November, 1931, Swezey (290) reported that all the buds fell off a few bushes at Honolulu and the result was no flowers. Larvae were also found at Manoa. The midges from these larvae emerged during December. Swezey (291) also reported another attack in Manoa valley on Tantalus White Hibiscus. In this case the buds did not fall off but the petals were somewhat crumpled. Felt (130) described both sexes. Fullaway (143) reported breeding this midge on *Pikaki*, *Jasminum sambac*. Recently, a most interesting study of the host plant range of the Hibiscus Bud Midge has been made by D. D. Jensen of the University of Hawaii Agricultural Experiment Station. His results show that midges originally found and reared on Hibiscus will breed on Tomato and midges originally found and reared on *J. sambac* also will breed on Tomato. Examination of the Hibiscus Midge and the Jasminum Midge reveal no structural differences. In addition, what appear to be the same species has been reared by Jensen and other workers at Honolulu from unopened blossom of Egg-plant, Garden Pepper, *Solanum rantonnetti* and Bitter Melon. The author is most grateful to D. D. Jensen for

informing him of his results before publication (341) and for donating to the Barnes collection specimens of all the above-mentioned rearings. The importance of this investigation lies in the fact that it has considerably extended the knowledge of the Hibiscus Bud Midge and has provided strong evidence that this species must be considered as probably identical with the Tomato Flower Midge (*Contarinia lycopersici* Felt) (see Vol. I, pp. 78–80). In addition, it has emphasized the great desirability of host plant range investigations in order to advance the knowledge of gall midge species relationships.

In India a gall midge, *Camptomyia hibisci* Felt, has been reared from larvae found in rotting stems of Hisbiscus at Coimbatore. Both sexes were described by Felt (128).

In Celebes Docters van Leeuwen-Reijnvaan (88) reported a small pustule on the leaf of *H. tiliaceus* L. which may have been caused by a gall midge.

In the U.S.A. *Neolasioptera hibisci* (Felt), the Mallow Stem Midge (121), was originally found in slightly enlarged stems of Rose Marshmallow, *H. moscheutos*, on Staten Island, N.Y. The larvae lived in the pith and occasionally in the outer tissues; either few or numerous (50–100) larvae could be found in a single stem. The midges emerged in late April. Felt (99) described both sexes and later (120) re-described them as well as giving descriptions of the larva and gall. In 1937 Imle & Hartzell (177) reared what Felt identified as this midge from various species of *Lilium* (see p. 84).

Trisopsis hibisci Felt was reared from the seed pods of *Hibiscus militaris* at Tallulah, Louisiana, in August, 1933, by R. W. Harned. The male and females were described (133).

HOLLYHOCK (*Althaea* (Tourn.) L.)

Larvae of a *Clinodiplosis* species (see p. 9) were sent by E. G. Hunt in the seed clusters of Hollyhocks from near Barnstaple, Devon, during September, 1934. Specimens are in the Barnes collection. Larvae, presumably the same species, were found by the author in samples of Hollyhock seed clusters received in 1934 and 1935 from Bedfordshire, Berkshire,

Cheshire, Cumberland, Derbyshire, Devon, Durham, Essex, Hampshire, Hertfordshire, Kent, Leicestershire, London, Middlesex, Norfolk, Northamptonshire, Oxfordshire, Shropshire, Somerset, Suffolk, Surrey, Sussex, Wiltshire and Yorkshire (27).

HONEYSUCKLE (*Lonicera* L.)

Several species of gall midges have been recorded from the various species of *Lonicera* L. in Europe, but none has been reported as a pest. The larvae of *Contarinia lonicerearum* (F. Loew) live in shortened and swollen flowers of *L. xylosteum* L. They are yellow and gregarious, pupating in the soil and emerging as midges the following year. In addition to this plant, Loew recorded the Common Elder (*Sambucus nigra* L.), the Dwarf Elder (*S. ebulus* L.) and the Mealy Guelder Rose or Wayfaring-tree (*Viburnum lantana* L.) as food plants. He described both sexes (202). The species occurs in Sweden (317), France and central Europe. In England it has so far only been reported on *V. opulus* L. More information concerning this midge may be found in Vol. III of the present work, and further references relating to its distribution are given in Houard (170). The food plants are given in Rübsaamen & Hedicke (263) as *Lonicera caerulea* L., *L. nigra* L. and *L. xylosteum*.

Five named species live on the leaves, namely, *Dasyneura periclymeni* (Rübsaamen), *D. xylostei* (Kieffer), *D.? excavans* (Kieffer), *Contarinia? lonicerae* Kieffer and *Macrolabis lonicerae* Rübsaamen. In addition to the galls with which these species are associated, three other malformations of the leaves or shoots of *L. xylosteum*, *L. caerulea* and *L. brachypoda* DC. are attributed to gall midges. References to the records of these latter unidentified gall midges can be found in Houard (170).

The larvae of *D. periclymeni* are reddish, gregarious and live in marginal leaf rolls (towards the upper surface) of *L. periclymenum* L. They pupate in the soil. There are two generations a year. Rübsaamen (249) originally described both sexes, the larva and gall. This species is on record from central Europe, Portugal (295) and England (10). Material in the author's

collection consists of males, females and larvae from Kinsbourne Green, near Harpenden.

Dasyneura? xylostei causes very small parenchymatous pustules on the leaves of *L. xylosteum* L. The galls have been recorded from Germany (256). Kieffer (194) gave the name to the gall only and the midges apparently have not yet been described.

D.? excavans causes a small excavation, 1 mm. in diameter, surrounded by a yellowish circular zone measuring 5–7 mm. in diameter on the upper surface of the leaves of *L. xylosteum* L. Each gall contains a solitary white larva. These galls have been recorded from central Europe (304) and Italy (59). Apparently the midges have not been described. Kieffer (194) gave the name to the gall.

Contarinia? lonicerae Kieffer is the name given by Kieffer (194) to a gall on *L. caerulea* L. which has been recorded from the Tyrol and Vorarlbergs (69, 71) and Italy (303). The gall consists of the terminal leaves being massed together. Apparently the midge has not yet been described.

The fifth European species is *Macrolabis lonicerae* Rübsaamen. Its larvae are white or yellowish-white and live in the same type of marginal leaf roll on *L. periclymenum* L. as do the larvae of *D. periclymeni.* Indeed, Rübsaamen at first thought they were inquilines of the *Dasyneura.* But since he found so many of the galls only containing the white larvae of the *Macrolabis* he reached the conclusion that this species was responsible for the same gall as the *Dasyneura.* It is unusual for *Macrolabis* and *Clinodiplosis* species to be gall formers, usually they are inquilines in the galls of other midges. Outstanding exceptions to this rule are *M. corrugans* F. Loew which is sometimes a pest of Parsnip (see Vol. I, pp. 64–7) and *C. hydrangeae* (p. 82). Rübsaamen (259) described both sexes of *M. lonicerae* which he found in Germany. Bagnall & Harrison (11) have recorded this species from Kent.

In the U.S.A. *Rhopalomyia lonicera* Felt causes an irregular ovate bud gall on *Lonicera subapicata.* This species was described (126) on the male reared from galls found in California. Miss Lois M. Ballou, who found the galls at Claremont, reported that the gall is characterized by a silk curtain across the

cavity. In addition, two other bud galls have been attributed (136) to a *Cecidomyia* species and an ?*Asphondylia* species.

HYDRANGEA (*Hydrangea* Cronov. ex L.)

In England a blister leaf gall (Plate 7, Fig. 1) has been found on *H. hortensis* by G. H. Pethybridge at Bodmin, Cornwall. Only the larvae of a *Clinodiplosis* species of gall midge were found in these galls, so it may be presumed that they were responsible. It is most unusual for a gall midge of this genus to make a gall. The galls were received at the end of June, 1933, and the midges emerged between July 30 and August 30 the same year. They were described by the author (30) as *C. hydrangeae*. Larvae as well as the cotype males and females are in the author's collection.

In the U.S.A. *Asphondylia hydrangeae* Felt causes the "Hydrangea bud gall" on wild Hydrangea, *H. arborescens*. Felt originally described the male (102) and later (119) re-described it, adding a short description of the gall. The latter is an elongate deformed bud, about 1 cm. in length, 3 cm. in diameter and yellowish or brownish in colour. The galls were collected in Virginia on April 28, 1884. The larvae changed into pupae within the gall on May 6 and the midges emerged between May 12 and 15. This gall was also found in Montana.

Another species of gall midge, *Angeiomyia spinulosa* Kieffer & Herbst (197), has been recorded from *H. scandens* Poepp. in Chile. Only the gall and larvae, which have a four-pointed anchor-process, are known. The gall is pea-shaped, being visible on both sides of the leaf and containing a single larva. The galls may be solitary or grouped in clusters.

Finally, Shinji described (271) in Japanese *Contarinia hydrangeae* which may be presumed to live on *Hydrangea*, possibly in the flowers.

IRIS (*Iris* Tourn. ex L.)

No gall midge has been recorded from cultivated Iris but a very interesting form lives on the yellow flag, *Iris pseudacorus*

L., in Europe. It is *Dicerura kaltenbachi* (Rübsaamen). The larvae are specially adapted to a semi-aquatic existence (187). Rübsaamen gave detailed descriptions of the larva, pupa and both sexes of the midges (255). Kaltenbach (180) had previously given the name *Cecidomyia iridis* to the larvae of this species. It is on record from Germany and England (16). In the last-named country it was found originally in 1926 by H. C. F. Newton at Dungeness, Kent. Larvae and pupae were found in the leaf sheaths on May 10 and 26. Midges emerged between May 26 and June 8. Midges of the next generation started to appear on June 28. It would seem therefore that there are at least two, probably three, generations a year in Kent. In Germany Kaltenbach found the larvae in June and July, while Rübsaamen found them in July and at the end of September, midges emerging in the following January. It is considered unlikely that midges would emerge out-of-doors so early in the year.

The apricot-yellow larvae, about 5 mm. in length, live in groups of four to six in the leaf sheaths low down on the plant. Their spiracles are specially adapted for the semi-aquatic conditions which are encountered in such a position. Pupation takes place within the leaf sheaths, the naked pupae also being found in groups. On the emergence of the midges the empty pupal cases are left in small rows half protruding from the leaf sheath and stem. The midges, which are pale orange to apricot-yellow, the males being paler than the females, are superficially reminiscent of the Box Leaf Mining Midge, *M. buxi* Lab., but are slightly larger, being 3–5 mm. in length. The three distal tarsal segments are whitish. The eggs, like the larvae, are apricot yellow to orange in colour. Specimens of the larva, pupa, males and females from Dungeness, Kent, are in the Barnes collection.

The only other record of a gall midge being found on Iris is that of Bagnall & Harrison (13) who found gall midge larvae "on Iris pods, twisting the fruit", in Yorkshire and Shropshire.

LILIES (*Lilium* Tourn. ex L.)

In Europe F. Loew (204, 205) recorded finding pale yellow gall midge larvae living gregariously in the unopened and swollen flower buds of *Lilium martagon* L. in Austria. They descended to the soil half-way through June. Loew thought it unlikely that this species was identical with *C. quinquenotata* (p. 78) which lived in similar malformations on *Hemerocallis fulva*. Apparently the midge itself has not yet been described, but Kieffer (194) named it *Contarinia lilii* on Loew's record of the larva and gall.

At the same time Kieffer (194) gave the name *C. martagonis* Kieffer to a second gall on this species of Lily. This gall consisted of the inflorescence being changed into a mass of aborted flowers with abnormally long and white pilosity. He also described the larvae which were gregarious and pale yellow. This gall was found at Budapest. Kieffer's propensity for naming midges on the larvae and gall or even the larvae only leaves much to be desired. In this instance, for example, are there in fact two distinct species of *Contarinia* involved (on *L. martagon*) or only one?

In the U.S.A., Imle & Hartzell (177) described stems of various species of *Lilium* as being heavily infested with the larvae of what Felt identified on reared midges as *Neolasioptera hibisci* (Felt) (see p. 79). The leaves and buds near the apex of the flowering stalk of nearly all the *L. auratum* Lindl. growing in nursery rows among evergreens at the Boyce Thompson Institute Arboretum in July, 1937, were blighted. The orange-coloured larvae were feeding in the pith and in some cases in the flower pedicels. In such cases the buds withered. In others the larvae had actually bored into the buds. The midges emerged in August through exit holes in the stems. *N. hibisci* was originally reared from *Hibiscus moscheutos*, the Swamp Rose Mallow, the stems of which were slightly enlarged. Imle & Hartzell, however, stated that there was no enlargement of the stems of *L. auratum* Lindl., *L. speciosum* Thunb., *L. tigrinum* Ker. or *L. formosanum* Wallace. Reports were also received that indicated that this midge was attacking *L. formosanum*, *L. spe-*

ciosum and *L. auratum* in other localities besides Yonkers, N.Y. Imle & Hartzell gave photographic illustrations of the damage on *L. auratum*, the larvae in the pith and the empty pupal cases sticking out of the stem.

LOBELIA (*Lobelia* Plum. ex L.)

Larvae of a *Clinodiplosis* species (see p. 9) were found among stored seed of *L. fulgens* at the Royal Horticultural Society's Laboratories, Wisley, Surrey towards the end of October, 1937. Specimens are in the Barnes collection.

Mesembryanthemum Dill. ex L.

Asphondylia mesembrianthemi Schiner was described (267) very briefly on the female. The larva were stated to live in pea-sized swellings on the stems of *Mesembryanthemum* species which occurred in great profusion on the sandy soil of Cape Vorlandes, Cape of Good Hope. Schiner's original illustration of the gall is reproduced by Houard (174). This midge apparently has not been found again and it is unlikely that it could be recognized with any certainty from the original description. However, it is included in this volume since the beautiful Livingstone Daisy is *M. criniflorum*.

MIMOSA (*Mimosa* L.)

Three species of gall midges have been described from Mimosa; two in the New World, *Asphondylia mimosae* Felt found in Texas, U.S.A. and *Schizomyia mimosae* Tavares in Brazil, and one from the Old World, *Dasyneura? mimosae* (Kieffer) in Egypt.

Asphondylia mimosae Felt was described (132) on the female only, and short descriptions of the empty pupal case and the bud gall were appended. Pupation takes place in the gall. The midges were originally reared in July, 1912, at Brownsville, Texas. *Ceratoneura pretiosa* Gahan was reared from this gall but it was not certain whether it parasitized the midge or another insect. Painter (232) stated that *A. mimosae* had been reared from two types of gall on *M. fragrans* A. Gray; the first

is a thin-walled oval gall formed from the enlarged and aborted ovary, while the second is a cone-shaped bud, thorn and petiole gall containing several orange larvae. The first type is found in clusters on the end of the flower peduncles and is often tipped by parts of a mature seed pod. He recorded that two males emerged from such galls towards the end of February, just before the spring appearance of the leaf buds and flowers. Midges were reared from the bud type of gall in November. Painter suggested that either these two galls developed side by side or that there might be a regular alternation between these two types of gall, just as he had found *Asphondylia prosopidis* Cockerell on Mesquite (*Prosopis glandulosa* Torr.) producing two distinct types of gall affecting the ovary. This latter species was re-described by Felt (134).

Schizomyia mimosae Tavares, of which both sexes were described (297), attacks the pods of *M. caesalpiniaefolia* Benth. The latter are slightly swollen and probably contain a single larva. Pupation takes place in the gall. It has only been recorded from Brazil.

Dasyneura? mimosae (Kieffer) occurs in Egypt on *M. nilotica* Desf. The midge has apparently not yet been described; Kieffer (194) named the gall. The latter consists of malformed leaflets which are curled and swollen. The larvae are red. Frauenfeld (140) was the first to mention the gall.

OLEARIA (*Shawia paniculata*)

The correct name of the New Zealand native shrub Akiraho or Akeake is now considered to be *Shawia paniculata* (*Olearia forsteri*, Hook. f., *O. paniculata* Cheesem). This shrub closely resembles *Aster* which it replaces in New Zealand. It is grown as an ornamental and for shelter.

For a long time it was thought that one species of gall midge was responsible for the galled buds and leaves which are so familiar. But Gourlay (153) realized that two species were involved, one forming blister galls on the leaves and the other making bud-galls. Miss Anderson's investigations (3, 4) seem to have cleared the matter up in a satisfactory manner.

Oligotrophus oleariae (Maskell, 1889), the Olearia Bud Gall Midge.

Diagnostic Character. Large excrescences consisting of numerous clustered rosettes of aborted leaves round the axils of the stems of *Olearia.*

Damage. As the result of an attack the axillary and terminal buds change into large excrescences which give the appearance of the original bud having proliferated into numerous buds whose growth has been arrested before they have had time to develop into young shoots; their leaves have remained small and their bases fused to form a multilocular gall. Occasionally small single-chambered rosettes occur where a single larva has been at work. More usually, however, neighbouring infested buds coalesce and so the compound galls are formed. As a consequence of an infestation, growth is seriously stunted. Often normal shoots do not appear until nearly midsummer, i.e. December onwards, all the previous attempts at growth being thwarted by midge infestation. The damage is clearly illustrated by Miller (224).

Miss Anderson (4) stated that occasionally a characteristic rosette gall is found growing out from the upper surface of a leaf.

Description. Maskell (212) first gave descriptions of this species but thought it was responsible for two types of damage —the bud gall and the leaf blister. Gourlay (153) realized that two species of midges were involved but assumed that the blister gall species was Maskell's *Cecidomyia oleariae.* But Miss Anderson (3) considered *C. oleariae* was responsible for the bud gall. This seems the more correct decision, especially as Maskell gave priority in type of damage to the excrescences of the young shoots and second place, as an alternative gall, to the blisters on the leaves. Miss Anderson re-described both sexes, placing the species in the genus *Oligotrophus.* She also described the morphology and anatomy of the immature and adult stages.

Distribution. Most parts of New Zealand (223).

Life History. The eggs, which are bright red, are laid in masses of 80–100 in the axils of the young developing shoots and leaves. In about 4 days, according to the temperature, the

larvae hatch. In two cases two larvae were found by Miss Anderson within the same egg-case. These are the only instances of twinning in gall midges known to the author and there seems little doubt as to this being the correct interpretation. Three larval stages were distinguished (cf. *Mayetiola destructor* which has three stages and *Dasyneura leguminicola* and *Monarthropalpus buxi* which have four instars). Very soon after hatching the larvae enter the plant tissue where they remain for about 9 months, each in a separate chamber and bathed in a fluid at least when young. The full-grown larva is white and has no breastbone. There is a prepupal stage lasting 3–5 days. Pupation takes place in the gall and lasts about 28–30 days. Emergence takes about 10 minutes and the midges live 1–2 days.

At Wellington oviposition occurs throughout October and during most of November; larvae are to be found from October to early August (full-grown larvae from the middle of July to the first week in August); the pupal stage chiefly in the middle of August; and the midges from about September 20 to the first part of November.

Food Plant. Olearia (*S. paniculata*), called by Maskell *Olearia furfuracea*.

Natural Enemies. The Proctotrupid, *Metaclisis oleariae* (Mask.) (212) lay its egg in the egg of the midge. The larvae develop in the ventriculus of the young host larva. They pupate within the hardened larval skin of the host. The duration of the pupal stage is just over a month, mid-August to the end of September, and the parasites are on the wing in October and November (3). Gahan (145) re-described this Proctotrupid.

A second parasite is a *Pteromalus* species. It can be found throughout the winter preying on the midge larvae. Pupae can be found at the end of September, while the adults are on the wing in December. Maskell confused the larvae of this parasite with those of the Proctotrupid mentioned in the preceding paragraph (3).

Control Measures. Miller (224) stated that the problem would be solved if the growing of *Olearia* or its susceptible varieties as ornamentals were stopped. He also suggested that

spraying throughout the spring with Black Leaf 40 (1 in 800) might reduce an attack, but stated that such spraying would have to be carried out at least two or three times a week. It is thus apparent that little really is known about any control, especially as the author can find no mention of any resistant varieties in the literature.

MATERIAL. Males, females and pupae. New Zealand (given by Miss Joan Anderson).

MOST IMPORTANT REFERENCES

MASKELL, W. M. 1889. *Trans Proc. N.Z. Inst. 1888*, **21**, 253–8 (*Cecidomyia*)
MILLER, D. 1922. *N.Z. J. Agric.*, **25**, 340–4 (*Cecidomyia*)
ANDERSON, JOAN A. T. 1935. *Proc. zool. Soc. Lond. 1935*, 405–20 (*Oligotrophus*).

Dryomyia shawiae Anderson, 1935, the Olearia Leaf-blister Midge.

DIAGNOSTIC CHARACTER. Blisters on the leaves of Olearia.

DAMAGE. The leaf chambers or blisters on the leaves never contain the transparent fluid characteristic of the larval chambers of the previous species. No gall is formed, only blisters. When the larvae are approaching maturity several blisters may fuse and in this way sometimes the whole of the inside of the leaf may be destroyed.

DESCRIPTION. Miss Anderson (4) described both sexes of this species separating it from *Oligotrophus oleariae* Maskell with which it was previously confused. *D. shawiae* is a slightly smaller midge. Miss Anderson, in addition, described the morphology and anatomy of the immature and adult stages, particularly pointing out how this species differs from the former.

DISTRIBUTION. New Zealand.

LIFE HISTORY. The eggs, which are red, are laid singly and vertically on the upper surface of the young leaves, the pointed end being embedded in the plant tissue. After about 3 days the larvae hatch and burrow immediately into the leaf-tissues. Here they remain throughout their larval, prepupal and pupal existence. In the last instar the larva is white and possesses a reddish-brown breastbone. The larvae are extremely active, whereas those of *O. oleariae* are sluggish. The mature larval stage lasts about 15 days. The prepupal stage lasts about 4 days.

The midges emerge through an exit which is a circular withered hole bored almost to the exterior by the mature larvae with their breastbones. Emergence takes about 10 minutes.

At Wellington eggs are laid from the beginning of October until the end of November. The larvae reach maturity at the end of July and in the first fortnight in August. A few very young larvae have been found at the end of August and mature larvae have been found in March but no midges ever developed from such specimens. The pupae first appear at the beginning of August, but the majority of the larvae do not pupate till after the second week in September. The midges start appearing on the wing at the end of September and continue until November. It will be noticed that this midge is slightly later than *O. oleariae*.

FOOD PLANT. Olearia (*Shawia paniculata*).

NATURAL ENEMIES. A Proctotrupid, *Metaclisis* species, and a Chalcid, *Pteromalus* species, parasitize the midge larvae. Both these species are smaller than their equivalents parasitizing *O. oleariae*.

CONTROL MEASURES. No control has been mentioned in the literature for this species, but that suggested for *O. oleariae* might be for some use.

MATERIAL. Larva, pupae, males and a female, New Zealand. (The midges are 2 out of the 3 cotypes males and 1 out of the 2 cotypes females originally designated by Miss Anderson who very kindly gave them to the Barnes collection.)

MOST IMPORTANT REFERENCE

ANDERSON, JOAN A. T. 1935. *Proc. zool. Soc. Lond. 1935*, 421–30.

ORCHIDS (*Cattleya* Lindl., *Laelia* Lindl., *Dendrobium* Sw., etc.)

One named species of gall midge, *Parallelodiplosis cattleyae* (Molliard), has been reported from orchids. In addition, a gall caused by an unidentified species has been reported from England and several other unnamed gall midges are on record from Java. Such sparse information and references as are available concerning the latter can be found in Houard (174). The

malformations are on the stem and the leaves of *Coelogyne tumida* J. J.Sm., *Eria oblitterata* Reich. f., *Eria vesiculosa* J.J.Sm. and *Polyantha laterifolia* King.

The English unidentified gall midge forms galls the size and shape of wheat grains at the extremities of the rootlets of *Dendrobium* species (336). Each gall contains a single orange-yellow larva whose breastbone differs in shape from that of *P. cattleyae.*

Parallelodiplosis cattleyae (Molliard, 1902), the Cattleya Midge
syn. *Clinodiplosis cattleyae* Felt, 1908.

DIAGNOSTIC CHARACTER. Spherical or elongate galls on the aerial roots of *Cattleya* species and *Laelia* species (Plate 7, Fig. 2).

DAMAGE. The galls are conspicuous swellings, sometimes attaining the length of 2 cm. and 1 cm. in diameter, but usually about the size of a large pea. Several larvae are to be found in the same gall but each larva lives in a separate cavity. Besides being unsightly, the galls reduce the growth of affected plants very noticeably.

DESCRIPTION AND SYNONYMY. The galls, larvae and midges have been known for a long time both in England (5, 67, 299, 336) and in the U.S.A. (229, 242). But Molliard (225) was the first to describe and name the midge. Felt (103) briefly described it as new under the name *Clinodiplosis cattleyae* and later (125) described in detail the empty pupal case as well as the male and female midges under the correct name of *P. cattleyae* (Molliard). The midges are orange in colour, the males being paler than the females. The larvae are a bright deep orange when full grown with a conspicuous brown breastbone.

DISTRIBUTION. Central America, England, France and the United States. In the last-named country it was originally reared in 1890 from roots sent in to the Bureau of Entomology from Massachusetts (125). Weiss (332) reported it in New Jersey and stated that orchids imported from Guatemala often had the roots badly disfigured by the galls of this midge, while Sasscer (265) reported collecting it from orchids sent from Brazil, Columbia, Guatemala and Mexico. Swezey (292) mentioned that while it had been intercepted in Honolulu several

times on imported orchids it was not known to have become established in Honolulu.

Life History. Little exact information is available. Several (1–7) larvae live in a single gall, each in a separate cavity. Pupation takes place inside the gall and, after the emergence of the midges, the empty pupal cases remain for a while half protruding. There are probably several generations a year. The original American specimens emerged during May, while the author has reared midges in August and September at Rothamsted Experimental Station.

Food Plants. Various species of *Cattleya* and *Laelia purpurata* Lindl. & Paxt. Molliard (225) recorded *C. sanderiana* Hort., *C. mendeli* Hort., *C. mossiae* Parker, *C. warneri* Moore and *L. purpurata* Lindl. & Paxt. as being attacked while *C. bowringiana* remained unattacked.

Felt (125) reported that *C. gigas* was the host plant of the midges he described. They were reared in 1890 from plants received from A. P. Morse, South Natick, Mass. Swezey (292) reported that this midge had been intercepted in Honolulu on *Cattleya mendeli*, *C. triumphans*, *C. warscewiczii*, *C. gigas sanderiana* and *Laeliocattleya* species from England; on *C. deckeri* from the Canal Zone; at Washington, D.C. on *C. warscewiczii sanderiana* from Columbia; and in Louisiana, on an orchid from Costa Rica.

Natural Enemies. No parasites or natural enemies have been recorded. Some early English entomologists, e.g. McLachlan (*in* 336), thought that the Cattleya Fly, *Isosoma orchidearum* Westw., was parasitic on this midge. Westwood, however, correctly considered that *I. orchidearum* was a plant-feeder. The mistake probably arose from the chance occurrence of midge galls and larvae on plants infested by *I. orchidearum.*

Control Measures. The cutting off and destruction of the galls or puncturing them originally suggested by Crawshay (67) is still probably the best method. Molliard (225) suggested that, after cutting off the galls and repotting the plants, they should be isolated in an uninfested house, preferably one which had not previously contained orchids. Theobald (299) stated that it was possible to extract the larvae with a fine-pointed knife

and that this treatment was successful if the larvae were not too numerous. However, there is always the danger of missing some of the larvae. Felt (113) said that fumigation had been recommended but that it would be inefficient owing to the difficulty of timing the fumigation to coincide with the appearance of the midge and before the eggs were laid and larvae entered the plant tissue. Swezey (292) mentioned a case in which the larvae of this midge had survived fumigation in Honolulu on plants imported from England. It is unsafe to rely on fumigation to kill this and other insects within plant tissues.

MATERIAL. Males, females and larvae. England (Hertfordshire).

MOST IMPORTANT REFERENCES

MOLLIARD, M. 1902. *Marcellia*, **1**, 165–70 (*Cecidomyia*)
THEOBALD, F. V. 1911. *J. S.-E. agric. Coll. Wye*, no. **20**, 194–5 (*Cecidomyia*).

PHLOX (*Phlox* L.)

Two species of gall midges have been reared by C. R. Neiswander from Phlox that had been severely damaged in Ohio. Greene (154) described the species that was responsible for the injury as *Hyperdiplosis phlox*. He described the male, female and last-instar larva but omitted to describe the exact nature of the damage, merely stating that all the material on which the species was described was reared from Phlox.

At the same time Greene also described the male, female and last-instar of *Lestodiplosis maculipennis* which was reared by Neiswander from the same material. This species is undoubtedly a predator on *H. phlox*.

RHODODENDRON and AZALEA (*Rhododendron* L., including *Azalea* L.).

Botanically, Azaleas and Rhododendrons are indistinguishable, but horticulturalists usually restrict the name Azalea to those forms which are deciduous and keep the name Rhododendron for the evergreens.

In the U.S.A. two species have been recorded on Rhodo-

dendron. *Asphondylia azaleae* Felt was reared from unopened, brownish, fusiform buds of *R. nudiflorum* during the latter half of June at Albany, N.Y. Normally only one larva inhabits each gall, but occasionally there may be two. Originally only the male was described (102), but later Felt described (119) the female and larva as well as re-describing the male. Felt (121) refers to the gall as the "Pinxter bud gall".

The second American species is *Giardomyia rhododendri* Felt (135). Both sexes were described, having been first reared by C. C. Hamilton. This species has caused considerable trouble in nurseries at Huntingdon Station, L.I., on *R. ponticum*, *R. maximum* and hybrid varieties. It has also been found on the native *R. maximum* in the Pocono mountains of Pennsylvania and on Rhododendrons at White Plains, N.Y. Felt states that this species is somewhat generally distributed in an area within 50 miles of New York City. The white larvae of this species cause a spotting of the foliage, rolling of the leaf margins and, when numerous, a malformed stunted terminal growth (337). The injury is limited to new growth and appears in late May or early June and then again on the second growth occurring in August. The larvae are only found in the younger tightly rolled leaves. When full grown they descend to the soil and it is then that the spotting on the leaves becomes noticeable. White (337) states that frequent applications of a contact insecticidal spray (nicotine-soap) have afforded practical control under field conditions. This species is represented in the author's collection by a single slide bearing males and females and labelled "Rhododendron tips. Huntingdon Station, L.I., U.S.A., August 20, 1938, C. C. Hamilton". It was very kindly presented to the Barnes Collection by E. P. Felt.

In central and western Europe various workers (36,268) have recorded a gall on alpine rose, *R. ferrugineum* L.; this consists of a mass of leaves resembling a bud and is situated at the extremity of the stem. Kieffer (194) gave the name of the midge causing this damage as *Dasyneura* (*Perrisia*) *rhododendri*, but apparently he had not seen the midge, of which no description can be found in the literature. Bagnall & Harrison (10) recorded this gall from Yorkshire.

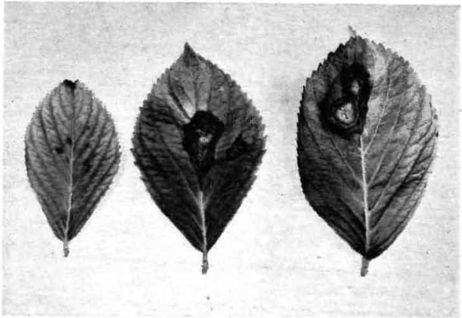

Fig. 1.—Leaf Blister Galls on Leaves of *Hydrangea hortensis* caused by *Clinodiplosis hydrangeae*. (*Photograph by V. Stansfield*)

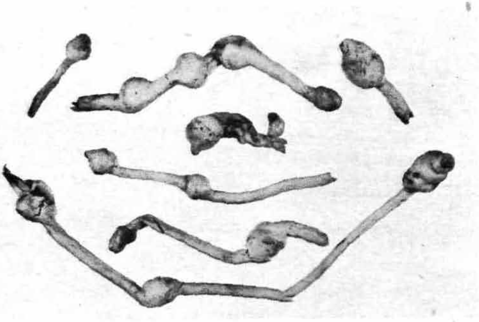

Fig. 2.—Galls of the Cattleya Midge, *Parallelodiplosis cattleyae*. (*Photograph by V. Stansfield*)

PLATE

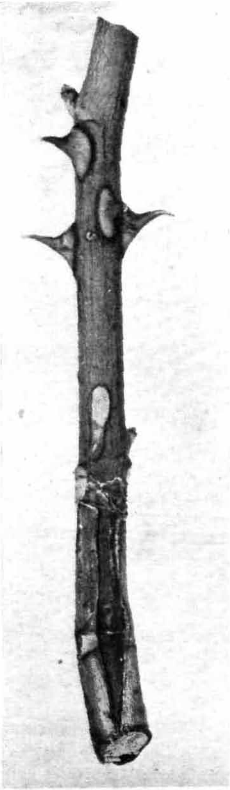

Fig. 1.—Newly Budded Rose Shoot.

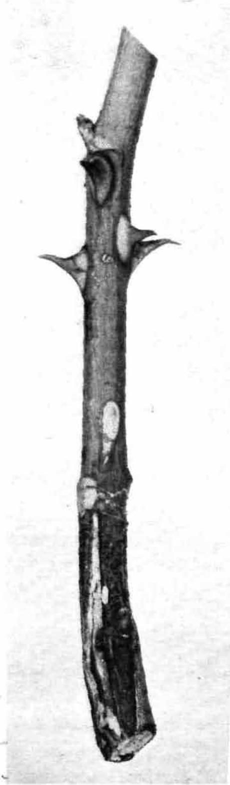

Fig. 2.—The same with the Bud re[illegible] revealing Larvae of the Red Borer, *Thomasiniana oculiperda*

(Photographs by V. Stansfield)

Rhus cotinus L.

Kieffer described (190) both sexes of *Contarinia cotini*. The white larvae are gregarious, one to four living in the swollen flowers of *R. cotinus* L. Kieffer reared this species in May, 1901, from larvae sent him in 1900 from Budapest by Szpligeti. F. Loew (203) has previously recorded the larvae in Austria.

In the U.S.A. three species of gall midges have been described from other species of sumac (*Rhus* spp.). *Dasyneura rhois* (Coquillet) causes globose root galls on the common Poison Oak or Poison Ivy (*R. toxicodendron*). The male and female midges as well as the gall were described by Coquillet (55) from New York State material. The midges emerged during May. Felt (111) stated it had not been found again and later (121) called the gall the "sumac root gall". Still later (136) he referred to it as the "poison oak root gall". *Parallelodiplosis cinctipes* Felt (109) was described on the male only reared in May, 1908, from dead twigs of *R. vernix* received from C. A. Frost, Framingham, Mass. *Asphondylia integrifoliae* Felt was first reared from *R. integrifolia* in Los Angeles County, California. Later it was reared from *R. trilobata* near Salt Lake City, Utah. The first mention of *A. integrifoliae* was in one of Felt's earlier keys to species (103), but later (119) he gave detailed descriptions of the female based on the Californian material and of the male based on the Utah material. The gall is a subglobular flower bud gall and was termed the "sumac bud gall" by Felt (121) when he figured it.

ROSES (*Rosa* Tourn. ex L.)

There are ten named species of gall midges associated with roses: namely, the Rose Rosette Midge, *Rhabdophaga rosacea* Felt, in North America, which forms a terminal rosette gall and has only been reported on two occasions; the Rose or Rose Bud Midge, *Dasyneura rhodophaga* (Coquillet), which injures the flower and leaf buds as well as the young shoots and has been an important pest of roses in the U.S.A. and Canada, especially of roses grown under glass; the Rose Leaf Midge, *Wachtliella rosarum* (Hardy), whose larvae live in the leaflets most commonly in Europe but also in the U.S.A.; *Macrolabis luceti*

Kieffer whose larvae are commensal with those of *W. rosarum*; *Dirhiza rhodophila* (Hardy), a British species whose identity is hard to establish but was stated to live in a gall like that of *W. rosarum*; *Clinodiplosis rosiperda* (Rübsaamen), a European species whose larvae inhabit the flowers of cultivated rose trees; the European Red Bud Borer, *Thomasiniana oculiperda* Rübsaamen, which is sometimes a serious pest preventing successful grafting of roses as well as fruit trees; the Rose Aphid Midge, *Phaenobremia rosivora* (Coquillet), whose larvae are predaceous on aphids; and lastly two species, *Mycodiplosis coniophaga* (Winnertz) and *M. reaumuri* Kieffer, whose larvae are fungus-eaters. These last three species will be dealt with in Vol. VIII.

In addition, Kieffer (191) recorded from Great Britain a closed gall situated near the extremity of branches of *R. spinosissima* and caused by an unknown Cecidomyid. The galls are 5–40 mm. long and the larvae red. The gall is accompanied by a twisting and thickening.

Bagnall & Harrison (10) mentioned yellowish gall midge larvae found feeding on mildew on rose in Durham. Hardy (162) was also acquainted with these larvae.

Lastly, G. E. Deacon (*in litt.* 27.3.35), stated that he frequently found the larvae of a *Clinodiplosis* species in rose shoots in Norfolk. The author has not been able to obtain any material of this species. It may be *C. rosiperda* (Rübsaamen) (see p. 109).

The three most important gall midges, *Dasyneura rhodophaga*, *W. rosarum*, including its inquiline *Macrolabis luceti*, and *Thomasiniana oculiperda*, receive attention first.

Dasyneura rhodophaga (Coquillet, 1900), the Rose Bud Midge.*

Diagnostic Character. Flower and leaf buds and young shoots of Roses distorted, turning brown and dying.

Damage. No flowers are produced on infested plants. Infested flower buds usually turn brown or black and die, while infested leaf buds result in the death or malformation of the young shoots. A favourite point of attack is the young

* Also called the Rose Midge (this is the official common name in America [230]). The Rose Bud Midge has been preferred as indicating the part of the

shoot in a leaf axil. Growers of roses under glass both in the U.S.A. and Canada have suffered considerable losses due to this midge. For example, Davis (72) stated that the midge had caused several Chicago growers thousands of dollars loss annually for the past 10 or 12 years; later Davis (73) estimated the loss in two Chicago greenhouses as approximately 10,000 dollars annually. A grower at Colgate, Md., stated his loss in the autumn of 1916 as between 4,000 and 6,000 dollars (266). In Canada, Ross (246) stated that in one Ontario greenhouse a loss of 12,000 dollars had been sustained in 1919 and in another a 6,000–7,000-dollar loss.

This midge originally was a glasshouse pest, but it was found attacking roses grown out-of-doors at London, Ontario, in Canada in July, 1914 and 1915 (165, 166). The first record of its occurrence out-of-doors in the U.S.A. was that of Crosby & Leonard (68). No further reports of its outdoor occurrence appeared until those of Weigel (325, 326), who wrote that it was seriously threatening outdoor roses in the U.S.A. and its appearance over a considerable area for three successive years (1935–8) had established it as an outdoor pest. All kinds of roses were being attacked and the damage was the same as that in glasshouses. Sometimes the first crop of roses escaped damage but from the middle of July until the August frosts the injury was prevalent. Weigel stated that in 1935 it was reported out-of-doors in Michigan, Ohio, two localities in New York State and in Indiana. In 1937 it appeared outside in Indiana and Virginia. In 1938 a similar infestation occurred at Washington, D.C. Blauvelt (40) came to the conclusion that, other factors being equal, gardens well protected by hedges, trees, buildings and other windbreaks were usually more heavily infested than plantings in more exposed positions. The midges being weak flyers can easily be prevented from egg laying by even moderate winds (cf. the Black Currant Leaf Midge, Vol. III, p. 65).

Description. Coquillet (56) originally described this species erecting the genus *Neocerata* for it. Felt (111) re-described both sexes and his descriptions are quoted by Sasscer & Borden (266). Felt placed it in the genus *Dasyneura* although the

antennae were not quite typical of this genus. Webster (324) described the immature stages. He also gave coloured illustrations of the damage, the egg, the larvae, pupae and the midges. Later Sasscer & Borden modified Webster's descriptions.

Distribution and Historical. North-eastern U.S.A., Canada and possibly England.

The earliest record is that of Asmus (9), who found it in rose-houses in New Jersey. Hammond (161) next reported it from New York State. Coquillet (56) recorded it from Massachusetts in 1894 and Chicago, Ill., in 1897. It was sent to the Bureau of Entomology from Ohio in 1903 and a heavy infestation occurred in Rhode Island in 1911. Snodgrass (277) reported it from Indiana, Sasscer & Borden (266) studied it in Maryland during an infestation at Colgate in 1916 and Fracker (138) recorded its introduction into Wisconsin.

The first definite Canadian records are those of Hewitt (165, 166) who reported it in 1915 as occurring out-of-doors in a garden at London, Ontario, and later (167) in greenhouses in Toronto. But Ross in 1921 stated (246) that he had been informed by the Superintendent of the Dale Estate, Brampton, that a pest, he believed to be the Rose Midge, had been present 15 years previously at Brampton. Gibson (150) recorded it in greenhouses at Toronto, Ont. Ross & Caesar (247) stated it was present in 1919 in six large greenhouses in Ontario, three in Toronto, one at Grimsby, one at Port Dover and one at Brampton. It does not appear to have been found in Canada outside Ontario. Its occurrence in Canada has frequently been traced to introductions from the United States.

Bagnall & Harrison (10) state that larvae found in the buds of cultivated roses in Northumberland are possibly referable to this species.

Life History. This has been studied in glasshouse infestations by Webster (324), Davis (73) and Sasscer & Borden (266). Additional information can be found in Weigel & Sasscer (328) and Gibson & Ross (151).

The female midge oviposits on succulent growth under the sepals and petals of the flower buds, in the axils of young leaves and between unfolded leaves of leaf buds. Under

favourable conditions the larvae hatch in two days. The feeding of the larvae on the sap causes the buds to shrivel and dry up, while those feeding on the upper surface of the young leaves and leaf petioles result in crooked growth, distortion, browning and ultimately death. As many as thirty larvae have been found in a single flower bud. The larvae are full grown in 5–7 days. At first white they become orange to red in colour on approaching maturity. When fully fed they drop to the soil where they pupate in cocoons. The midges emerge in 5–7 days and as usual among midges live only 1–2 days. The whole life cycle under glasshouse conditions is completed in 12–16 days.

The exact number of generations per year has not been stated, but the midges are reported as being present in injurious numbers from May to November in glasshouses. The most serious damage is done from May to July and from September until early November; no injury has been reported during the winter months, although larvae have been found in the buds as early as February 22. The winter is presumed to be passed in cocoons in the soil. Gibson & Ross (151) state the midges reappear in March.

Apparently no detailed study of this midge's life history out-of-doors has yet been made.

Food Plants. Glasshouse Roses and also Roses grown out-of-doors. Hybrid Tea and Hybrid Perpetual Roses are particularly attacked. Varieties with strong terminal shoots are relatively immune.

In the U.S.A. this midge has been recorded in glasshouses on the following varieties: American Beauty, Bridesmaid, Columbia, Duchess of Albany, Golden Gate, Hadley, Hoosier Beauty, Ivory, Joe Hill, Kate Moulton, Killarney, La France, Liberty, Madame Butterfly, Madame Chatenay, Meteor, Mrs. Aaron Ward, Mrs. Charles Russell, Mrs. George Shawyer, Mrs. John Laing, My Lady, Ophelia, Radiance, Richmond, Sunburst and Uncle John.

Dealing with an outdoor attack on Long Island Weigel (326) stated that Betty Uprichard seemed very susceptible whereas Étoile de Holland, Jonkheer, J. L. Mock, Madame Butterfly and Ville de Paris were not so severely attacked. Dorothy

Page-Roberts and Duchess of Wellington were only slightly attacked, while Lady Alice Stanley appeared free. New growth on Polyantha Roses showed signs of attack but no larvae were actually found. Charles K. Douglas was the most severely attacked among more than thirty varieties. Climbing Madame Butterfly and Climbing Los Angeles appeared very susceptible.

In Canada, Hybrid Teas and Hybrid Perpetuals were attacked out-of-doors in a garden at London, Ont., the variety Mrs. John Laing being most severely injured. Hybrid Perpetuals with strong terminal shoots like Killarney, were practically free from attack, while all the Polyantha, Bourbons, Hybrid China, Noisette and Wichuriana appeared to escape the midges' attention. Of glasshouse varieties, Ophelia, Columbia and Milady have been recorded as the varieties most attacked, while Russell, Stanley, Ward, Richmond, Shawyer, Hoosier Beauty, Sunburst, and to a slight extent Killarney have also been damaged.

NATURAL ENEMIES. None has been recorded.

CONTROL MEASURES. The papers of Sasscer & Borden (266), Ross (245, 246), and Gibson & Ross (151) should be consulted for glasshouse control measures, while those of Blauvelt (40, 41) and Weigel (326) deal with outdoor control measures.

It should be possible to prevent its introduction into glasshouses if certain elementary precautions are taken. Stock should not be bought from nurseries known to be infested. Earth round the roots should not be brought into the glasshouses. New stock should be introduced before the end of February and, if possible, kept isolated for a while after careful examination.

Houses where the pest has become established can be completely cleared of the pest by either of the two following methods. An alternative crop can be grown for one year or the houses can be cleared out and new stock introduced. The latter method involves the destruction of all the rose plants and the removal of the soil in mid-winter. Neither of these methods usually recommends itself to commercial growers owing to the cost and upsetting of the normal business.

Several methods (cultural, fumigation, application of dusts

to the soil and spraying), however, have been evolved and used successfully in commercial houses, for keeping down the numbers of midges so that the damage is negligible.

One such method has been to change the soil annually during early May and June accompanied by the destruction of infested buds as soon as they are seen.

Another has been fumigation also accompanied by picking off and destroying any infested shoots. Tobacco stems were originally used for the fumigation but the use of nicotine is preferable since tobacco stems are not everywhere easily obtainable and their nicotine content is variable and not readily ascertainable. Fumigation for 3 or 4 weeks in the spring was found to be insufficient, but when the houses were fumigated every other night from early April until the end of October the damage due to the pest was negligible. One drawback is the fact that some growers maintain that frequent fumigation stunts the plant growth, another is the great cost.

A further method that has proved satisfactory in keeping down the numbers is fumigation accompanied by the application to the soil of tobacco dust. Sasscer & Borden (266) found that if the soil was covered ¼ to ½ inch with dry tobacco dust the midge larvae could not enter the soil. In their experiment the soil was so covered on October 12, the paths were sprayed with kerosene emulsion and nightly fumigation was done until October 30 and then every other night until November 8. The fumigation was to kill the midges before egg laying, the nicotine dust to prevent the larvae entering the soil, and the spraying to prevent the larvae penetrating the paths. As a result of this campaign the midge was practically exterminated.

Sasscer & Borden's methods were modified by Ross who found that the application of tobacco dust alone was satisfactory and so the great expense of nightly fumigation was saved. Ross's method was tried commercially with great success. An establishment with 250,000 square feet of glass containing 85,000 rose plants was heavily infested. In the second week in August the fallen leaves were all removed and the soil tamped to level the surface. Thirty-five tons of tobacco dust was scattered the entire soil

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surface after the latter had been thoroughly drenched with water. The paths were sprayed with kerosene emulsion. For 2 weeks after the application of the dust the beds were not watered, only the foliage occasionally syringed. This was to prevent washing the nicotine away before all the larvae present in the shoots had dropped to the soil. The results were entirely satisfactory. Equally good results were obtained when other commercial houses were similarly treated at other times in the year, namely in mid-July, mid-August and September.

Ross also suggested that drying off all the rose plants at the same time during the summer would cause an absence of new tender plant growth and so result in a shortage of oviposition sites for the midges. This method, however, does not appear to have been tested.

Hydrocyanic gas fumigation has not proved satisfactory.

Coquillet (56) stated that the liberal use of Persian insect powder * in one case and the use of Californian Buhach in another proved efficient in reducing the pest. These methods are mentioned since the use of pyrethrum powder instead of tobacco dust might help in reducing the cost. It is certainly worth further investigation.

Nicotine and pyrethrum sprays kill a large number of the midges present, but just as with the Chrysanthemum Gall Midge, emergence goes on rather continuously and so spraying has to be very frequent in order to get a good control by this method.

As regards control out-of-doors, Gibson (150) stated that the only satisfactory method was to cut off all the green shoots and to burn them. This was previous to the discovery of the glasshouse fumigation and tobacco dust methods described above. Fumigation of particular bushes or even beds might be accomplished out-of-doors by the use of tents. The method of covering the soil with nicotine dust or a tobacco stem mulch should also be of use outside, but care would have to be taken to nullify the leaching effect of rain by re-covering the soil after rain. Recently, Weigel (326) obtained a satisfactory

* Persian insect powder is made from *Pyrethrum* spp. flower heads, while Buhach is the commercial name for powder made originally near Stockton, California, by G. N. Milco, a native of Dalmatia, from the flower heads of *Pyrethrum cinerariaefolium*.

control out-of-doors by applying a mulch of tobacco stems (200 lb. to 300 plants) supplemented by spraying with nicotine sulphate and fish-oil soap and removing all infested tips.

The most recent development in the control of this midge in the open has been suggested for experimental use by Blauvelt (41). This has been soil fumigation involving the use of 90 per cent. dichloroethyl ether (14 fluid oz. to 1 gal.) with an emulsifier. A concentration of 10 c.c. per gal. of water applied at the rate of 1 gal. per sq. yard appeared to be best for repeated applications during the growing season. For a single autumn or spring treatment Blauvelt suggested the same concentration at 2 gal. per sq. yard. Summer treatment after the midge attack has become severe necessitates several applications at weekly intervals. Hybrid Teas, Hybrid Perpetuals and Floribundas showed very good tolerance to such treatments with dichloroethyl ether, but most Polyanthas were injured. This treatment was found unsatisfactory for greenhouse use and Blauvelt insists that further experiments are essential before this soil fumigation can be generally recommended even for use outdoors.

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Thomasiniana oculiperda (Rübsaamen, 1893), the Red Bud Borer.

Diagnostic Character. Pink to red larvae between bud grafts and the stock of fruit trees and roses (Plate 8, Figs. 1 and 2).

Damage. Since the larvae feed on the sap between the two layers of cambium the scion fails to unite with the stock and

the budding is a failure. Even when the graft has become partly welded to the stock, further growth is stopped. Moor (227) recorded this species attacking apricot, peach and pear trees during July and August, while Karsch (181) stated that whole rose nursery gardens were ruined during September and October. Fryer (142) reported failures in newly budded roses, apple and plum stocks. On one occasion, brought to the author's attention, 6,000 newly budded roses in a Nottingham nursery were completely destroyed in 1929 by attacks of this midge.

Description. Rübsaamen (252) first described this species. Originally described in the genus *Diplosis*, it was subsequently placed in the genus *Clinodiplosis* (184). Next Rübsaamen (258) made it the type of his new genus *Thomasia*. Finally, Strand (286, 287) gave the latter genus the present name *Thomasiniana* since *Thomasia* was pre-occupied. It is a typical Trifila * with regular circumfila, the claws are toothed on all the legs and the palps have four segments. The larvae are salmon-pink in colour when full grown, and almost white when very small.

Distribution. Germany (207), France (315), Denmark (137), Czecho-slovakia (276), Russia (81) and England. In the latter country Theobald (300) reported it in Herefordshire and Surrey, Fryer (142) Suffolk and Essex, Roebuck (*in litt.*) Nottinghamshire and Staniland & Umpleby (280) in the Bristol province.

Life History. The author has studied this species on rose and hesitates to generalize his findings concerning its life history on this plant and what may occur on fruit trees.

The female midges lay their eggs between the bud-grafts and the stock and in fact in any fresh slit or scratch whether artificial or natural (21). They will not oviposit on sound or unabrased stems. It had been previously stated (278) that the larvae lived in wounds of roses and other Rosaceous plants and in grafts, the females ovipositing in fresh wounds. Several eggs are laid at a time. As many as eighteen larvae have been found

* The Trifila group of the Cecidomyiariae is distinguished from all other groups of the Cecidomyiinae by possessing three whorls of circumfila on the male flagellate antennal segments. The Bifila, e.g. *Contarinia* spp., have two whorls.

in a single rose bud-graft. The following figures of the numbers of midges reared will give a better idea of the numbers of larvae present in a severe infestation of budded roses. The material was collected by A. Roebuck in Nottingham in September, 1929: from 12 buds, 94 midges; from 12 buds, 74 midges; from 14 buds, 225 midges; and from 14 buds, 142 midges. The larvae spend all their feeding period between the bud and the stock or in the slits. Pupation takes place in the soil at a depth of about 2 inches (81) and larvae of the last generation pass the winter in the soil. There are three generations a year.

In breeding experiments in an unheated insectary at Rothamsted Experimental Station in 1930 the midges laid eggs in artificial slits on rose trees. The first flight of midges took place from May 21 until June 23. Larvae of the first generation were full grown by about June 16. Midges of the second flight (completion of first generation of the year) appeared between July 5–16 and July 18–August 7, the shortest period for complete development being 40–43 days. Larvae of the second generation were full grown and crawling out of the slits to the ground by July 30, having taken about 3 weeks to develop. Midges of the third flight (end of second generation) appeared from August 21–25 until September 1–2, the shortest period for the generation to be completed having been 47–50 days. It is the third generation larvae present in September that coincide with rose budding in some parts of England and therefore do most damage.

This species breeds by means of unisexual families as the author (21) showed.

Food Plants. Roses and fruit trees, including Apple, Apricot, Pear, Peach and Plum.

Owing to the similarity between this species and the Raspberry Cane Midge (*T. theobaldi* Barnes), experiments have been carried out to ascertain whether *T. oculiperda* would oviposit on cut and scratched stems of Lloyd George variety of Raspberry. Negative results were always obtained.

Natural Enemies. No parasites or predators have yet been discovered, although considerable numbers of the midge larvae gathered in the field have been reared.

CONTROL MEASURES. The method of control adopted is to prevent the females ovipositing. Karsch (181) was partly successful in preventing development of the larvae by using cottonwool soaked in naphthalene. Fryer (142) recommended as a preventative tying up the grafts with woollen thread previously dipped in turpentine mixed with a little linseed oil and naphthalene and then thoroughly dried. Dessiatov (81) suggested the use of a 2-inch bandage of cotton thread underneath the raffia or the smearing of the grafting-point over the raffia with garden pitch. Staniland & Umpleby (280) prevented attacks on apple and rose stocks by coating the buds thoroughly, immediately after tying, with ordinary vaseline. Callus formation was greatly increased and the percentage "take" of buds was not affected. These investigators found that, while the use of palm oil and coconut oil prevented oviposition, oils damaged the buds. Reichert (239) recommended using a thick paste of clay to cover the grafts.

For surface grafting the method of earthing up the grafts has been used successfully in practice for a long time.

CLOSELY ALLIED SPECIES. The Raspberry Cane Midge (*T. theobaldi* Barnes), the Hawthorn Stem Midge (*T. crataegi* Barnes), and the (possibly another) species of the same genus which attacks *Ribes* (see Vol. III, p. 70).

These species of *Thomasiniana* are morphologically and biologically very similar and the author (28) made a comparison of the three named species. On one occasion a male *T. oculiperda* mated a female *T. theobaldi* but no progeny developed.

The main biological points of similarity are: the characteristic flattened resting attitude of the midges; the afternoon emergence and evening oviposition period; the occurrence of unisexual families in the three species; the oviposition under grafts or in wounds by *T. oculiperda*, in wounds by *T. crataegi* and in wounds and under the broken skin by *T. theobaldi*. The biological differences include the occurrence in the field on different food plants (*T. oculiperda* on Rose and Apple, Apricot, Pear, Peach and Plum among fruit trees; *T. crataegi* on Hawthorn; and *T. theobaldi* on Raspberry and Blackberry).

MATERIAL. Males, females and larvae, England (Somerset, Surrey, Gloucestershire, Nottinghamshire). From Rose and Apple.

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Wachtliella rosarum (Hardy, 1850), the Rose Leaf Midge.

DIAGNOSTIC CHARACTER. Folded leaflets of *Rosa* species containing orange-coloured larvae. White larvae in the same galls are those of its inquiline gall midge, *Macrolabis luceti*.

DAMAGE. The two halves of the leaflets are folded upwards along the mid-vein until they touch forming a pod-like open gall. Sometimes they are slightly swollen, have a blistered appearance and are tinted red. The damage is unsightly rather than serious, and is more common on wild than on cultivated roses. However, if the majority of the leaflets of a rose tree were to become infested, real damage might result owing to the diminished area of effective leaves. Reichert (329, 240) deals with it as a pest of roses.

DESCRIPTION. Hardy (162) originally described the female. Its abdomen is dark salmon-red in colour and covered with bands of black scales. Rübsaamen (261) separated it from other *Dasyneura* species and placed it in his newly erected genus *Wachtliella*.

DISTRIBUTION. Throughout Europe, including Sweden (317), on the coast of the Baltic (200), Denmark (248), France, Germany, in the Tyrol and Vorarlbergs (71), Hungary (293), Italy (14), Sicily (283, 284), Norway and the British Isles, and in the U.S.A., New York State (111) and Massachusetts (305). Other citations for its European distribution can be found in Houard (170) and Barnes (17). In addition, Miss Dombrowski (90) recorded it from the Kamennaja Steppe, U.S.S.R. and (*in litt.* 19.10.37) from the Khibin, the centre of the European part of the U.S.S.R., and from the Caucasus.

In Great Britain, Bagnall & Harrison (10) stated that it had been found in all the northern counties except Westmorland and Cheshire, Falconer (96) recorded it from Lancashire, Burkill (47) recorded it from Staffordshire, Zimmerman (339) from Kent, Harrison (163) at Waldridge Fell in Durham, W. E. H. Hodson (*in litt.* 13.6.28) from Devon. Trail (306) recorded it from Scotland, Miss Malone (208) recorded it from Co. Armagh and Co. Tyrone and the author has found it in Caernarvonshire, North Wales and near Bedford.

Life History. The eggs are laid in the unopened leaves which consequently fail to open. Up to 50 larvae may be found in a single leaflet. The winter is passed as larvae in the soil. Reichert (240) states there are two generations a year. The author has reared midges between October 16 and 29, 1937, and May 12 and June 30, 1938, from galls collected early in September 1937. It is possible that this species breeds by means of unisexual families since in this breeding exactly fifty females were reared and no males. On the other hand, the male larvae may have left the galls before the latter were collected, but such a clear-cut demarcation seems hardly likely.

Food Plants. Many species of *Rosa*. Houard (170) lists the following species: *R. agrestis* Savi, *alba* L., *alpina* L., *apricorum* Ripart, *bibracteata* Bastian, *bernardi* Rouy, *canina* L., *carelica* Fries, *cinnamomea* L., *coriifolia* Fries, *dolichocarpa* Boullu, *dumetorum* Thuill., *farinosa* Bechst., *glauca* Vill., *glauca* Vill. f. *complicata* Christ., *indica* L., *montana* Chaix, *pomifera* Herrm., *pseudoelliptica*, *rubiginosa* L., *sempervirens* L., *spinosissima* L., *stenophylla* Rouy, *tomentella* Léman, *tomentosa* Smith and *villosa* L. The authorities who originally recorded the Rose Leaf Midge on these species of rose are all given.

The references rarely refer to cultivated roses, but among the latter varieties the author has found it on Shot Silk.

Natural Enemies. Mayr (218) recorded *Torymus abbreviatus* Boh. as an ectoparasitic larval parasite. Felt (111) reared *Torymus ostensackenii* D.T. from the galls of this midge. Huber (175), quoting Felt, includes *Callimome sackeni* Ashmead as a parasite of this gall midge in his taxonomic review of Chalcids.

The predaceous gall midge, *Lestodiplosis rosarum* Barnes (18), was reared during August, 1925 from the galls of *W. rosarum* found in Kent. The type male is in the author's collection.

INQUILINE. The larvae of *Macrolabis luceti* Kieffer (186) live as inquilines in the galls of *W. rosarum*. They are white in colour and pupate in the soil. Kieffer gave a short description of the midges. It is a western, central and southern European species, having been found in France and Italy (182, 196). Bagnall & Harrison (11) recorded it on *Rosa spinosissima* L. (*R. pimpinellifolia* DC.) and *R. reuteri* in Northumberland and Durham, while Miss Malone (208) collected it in Co. Armagh and Co. Tyrone. It is probably as widely distributed as *W. rosarum*.

CONTROL MEASURES. Reichert (240) stated that *W. rosarum* can be controlled by destroying the infested leaves. Care must be taken however to pick the leaves while the larvae are still in them.

MATERIAL. Females and larvae, Wales (Caernarvonshire).

MOST IMPORTANT REFERENCES

HARDY, J. 1850. *Ann. Mag. nat. Hist.*, (**2**) **6**, 186 (*Cecidomyia*)
REICHERT, A. 1932. *Kranke Pflanze*, **9**, 44–5 (*Dichelomyia*)
REICHERT, A. 1933. *Kranke Pflanze*, **10**, 156–7 (*Dasyneura*).

Clinodiplosis rosiperda (Rübsaamen), of which both sexes were described (250), is on record from Westphalia (250), Lorraine (188), Sweden (317) and Great Britain. In the last-named country Bagnall & Harrison (10) found it in Durham, Northumberland and Yorkshire. The larvae, which are reddish-yellow to orange-red, are stated to live at the base of the petals of cultivated hardy roses and to pupate in the soil. Their presence is revealed by half-open roses which dry up without fully opening. On the continent *Rosa centifolia* L. is recorded as the host plant while in England it is *R. villosa* L.

Dirhiza rhodophila (Hardy) was described (162) on a female found at Penmaenshiel and bred from a gall similar to that of *W. rosarum*. No further information regarding this species is available except a record of its occurrence in Northumberland and Durham by Bagnall & Harrison (10) which could equally

well refer to *Macrolabis luceti*. These investigators stated that the larvae were white and occurred in galls similar to those of *W. rosarum*. The bionomics of *Dirhiza rhodophila* are practically unknown. It may be a gall former or a coprophile or inquiline in the galls of *W. rosarum* or it may even have been an accidental contamination of the breeding-cages in which Hardy was rearing *W. rosarum*. The identity of the species and genus are hard to establish. Apparently no gall midge answering its description has since been reared from rose leaflets. Caught gall midges referred by F. W. Edwards to the genus *Dirhiza* are in the British Museum (Nat. Hist.) as well as a single female in the author's collection. This latter specimen was kindly donated by F. W. Edwards in 1937.

Rhabdophaga rosacea Felt, the Rose Rosette Midge, was described (103) on a single male received from N. Criddle, Awema, Manitoba on May 15, 1906. Felt (111) states that the gall of presumably the same species was found on September 30, 1907, by L. H. Weld on a wild rose at Beach, Ill. In this case the larvae was a pale orange. The gall (figured by Felt) is an apical, loose, bud gall, 2–2·5 cm. in diameter and 3–3·5 cm. long. A single pinkish larva lives in an elongate central cell. Felt (111) re-described the male and gave short descriptions of the gall and larva.

SWEET PEA (*Lathyrus odoratus* L.)

Both sexes of *Clinodiplosis lathyri* Rübsaamen were described (262) from midges reared in the autumn of 1914 from red larvae living in normally shaped pods of the Sweet Pea (*L. odoratus*) in Germany. Pupation took place in the soil. It seems likely that this species may prove to be the same as *Clinodiplosis pisicola* Barnes which was originally described (19) from midges reared from larvae found in the pods of Sweet Pea at Aberystwyth, Wales and has later been found living as inquilines in the pods of the Garden Pea (*Pisum sativum* L.) infested by *Contarinia pisi* (Winnertz) (32). In this case *Clinodiplosis pisicola* Barnes would become a synonym of *C. lathyri* Rübsaamen.

TAMARISK (*Tamarix* L.)

The gall midges attacking Tamarisk are not easy to distinguish and identify satisfactorily. This is due to the incomplete information which is available concerning them, resulting from the difficulties involved in studying them thoroughly. Nevertheless, names have been given to seven species which form galls on the stems and branches and to one which attacks lateral buds. Five other galls have been attributed to unidentified gall midges. Only brief mention will be made here of the various species and their galls. Readers are referred to the works of Houard (170, 174) for more detailed descriptions, figures of the galls and additional references.

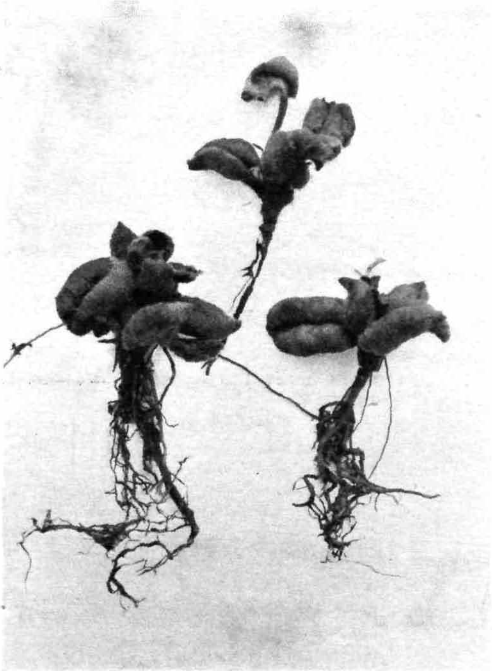
The generic placing of the stem gall-forming midges of Tamarisk is unsatisfactory. Three genera, *Amblardiella*, *Psectrosema* and *Isosandalum*, each with very narrow limits, have been erected for five species. (It is uncertain whether the remaining species, *Cecidomyia tamaricis* Kollar, is responsible for its stem gall or not.) Debski (76) considers that the differences between these three genera are purely artificial and it would be more natural to consider that there is one genus namely *Psectrosema*, with somewhat wider limitations, to which all the species causing fusiform stem galls on Tamarisk belong. Debski chose the genus *Psectrosema*, in preference to *Amblardiella*, because up to that time only the pupa of *A. tamaricum* had been described.

The gall of *Amblardiella tamaricum* (Kieffer) is ovoid or fusiform and situated towards the extremities of the leaf branches and on the flowering shoots of *T. africana* Poiret, *T. brachystylis* Gay, *T. brachystylis* var. *sanguinea*, *T. gallica* L. and *T. bounopaea* Gay. The wall of the gall is thin but tough, covered with small leaves or the inflorescence and chiefly green but often tinted with red on one side. There is a large cavity in which the solitary larva pupates. The empty pupal case is brown. The gall and pupae were first described and figured by Amblard (2) who found it in Algeria: the gall has since been recorded from Tunisia (171), Morocco (172) and Tripoli (312). Debski (75) considered that Frauenfeld's record (141) of its occurrence in Egypt was erroneous.

Kieffer (*in* 172) described and named the pupa of this species *Oligotrophus tamaricum.* Later Kieffer (195) made it the type of the new genus *Amblardiella.* The midges themselves were not described until much later (22). The bionomics of *A. tamaricum* have been studied by Dieuzeide (82, 83) in Algeria. In captivity, the eggs which are reddish orange are laid in clusters of about fifteen. In the laboratory the larvae hatch in from 5 to 7 days. Between March and May the midge breeds in galls on the flowering shoots; later in the year, from June to February, they are to be found in galls on the leafy branches. Midges are present throughout the year, but most emergences take place between December and mid-March. There are several overlapping generations a year. Dieuzeide obtained three parasites, *Platygaster cecconii* Kieffer which is also recorded as a parasite of *Helicomyia saliciperda* (Dufour) in Italy, *Eutelus tamaricum* Ferrière and *Tetrastichus annulatus* Forst. He also found small Myriapods, *Cylindroiulus africanus* or *distinctus*, in the galls, but H. W. Brolemann was of the opinion that their presence was purely accidental.

The second stem gall is that of *Psectrosema tamaricis* (Stefani). It also is fusiform, with a reddish surface, but is thick walled. It has been recorded on *T. gallica* L. and *T. tetranda* Poll. in Sicily (282), Portugal (294) and possibly Tunisia (172). The larvae which are vitelline in colour are gregarious and pupate in the gall. The empty pupal case is hyaline. The midges are on the wing during the winter and spring. Stefani (282) described, in the genus *Rhopalomyia*, both sexes, the larva and egg Bagnall & Harrison (12) recorded this species on *T. gallica* in Devon and Sussex.

A third stem gall is that of *Isosandalum provinciale* (Kieffer). This is a scarcely perceptible gall in the branches of *T. gallica* L. and so differs from the two preceding species. The larva which is red lives solitarily in a long narrow cavity. Kieffer (195) gave short descriptions of the pupa and both sexes. He stated that it was found in Provence and had been sent him from Marseilles. Tavares (295) recorded it from Portugal. Originally in the genus *Psectrosema*, Kieffer (196) dealt with it as the sole species in the genus *Isosandalum.*



Violet Plants badly galled by the Violet Leaf Midge, *Dasyneura affinis*. (*Photograph by F. C. Brown.*)

PLATE 10.

Fig. 1.—Galls of *Wachtliella ericina* on *Erica carnea* var. *atrorubra*. (Photograph by V. Stansfield.)

Fig. 2.—Plant of *Erica carnea* var. *atrorubra* heavily infested with galls of *Wachtlie ericina*. (*Photograph by V. Stansfield*)

Another stem gall is that of *Psectrosema debskii* (Kieffer). This resembles that of the previous species in being a long and scarcely visible gall on the young branches. Its wall is extremely thin. A single red larva lives in each gall. Kieffer (195) described the gall, pupa, midges and eggs. It was found in Egypt on *T. articulata* Vahl. Kieffer originally placed it doubtfully in the genus *Cecidomyia*; Debski (76) referred to it as belonging to the genus *Psectrosema*.

The fifth stem gall is that of *Psectrosema alfierii* Debski, which was found in Egypt on *T. arborea* Bunge. Debski (76) gives detailed descriptions of all stages, contrasting them with those of *P. debskii*. He had previously (74) mentioned the species without naming it and had given a short description of a single badly damaged male specimen, but this description was corrected in several points in this later paper. Among the differences between the galls of *P. alfierii* and *P. debskii* are the following: those of *P. alfierii* occur on the primary branches (which do not fall) and rarely on the secondary branches; those of *P. debskii* occur on the tertiary and quaternary branches and very rarely on the secondaries (secondary, tertiary, quaternary, etc., branches of *Tamarix* are shed regularly at the end of the year like the leaves in other plants, whereas the primaries are retained); the gall of *P. alfierii* is the normal green and sometimes brown, that of *P. debskii* pale green tinted with red; and the galls of *P. alfierii* after emergence of the midges remain on the Tamarisk and continue to function as part of the normal plant, whereas those of *P. debskii* die whether they are situated on those branches which normally are shed or not.

Debski considered that *P. alfierii* resembled *P. debskii* more closely than *I. provinciale* on account of the formation of the top of the head, the fusion of the third antennal segment with the fourth, the pulvilli being equal in length to the claws and twice as long as the empodium and the proportions of the tarsal segments and the two last flagellar segments of the antennae. But considering the pupa and the gall, Debski thought it was closer to *Amblardiella tamaricum*.

The gall of *Dasyneura? tamaricina* (Kieffer) was described and

named by Kieffer (194). It was first observed and figured by Frauenfeld (141), who found it in Egypt on *T. africana* Poiret. It is an axillary bud gall in the shape of an artichoke and reminiscent of similar galls on oak, willow and yew. Scales surround the larval cavity. Apparently the midge itself has not yet been described.

Debski (74) gave the name *Dasyneura tetragynae* to the midge whose larvae cause the flower buds of *T. tetragyna* in Egypt to remain closed. The larvae are orange and gregarious. Pupation takes place in the soil. The midges were not described.

Mani (209) described both sexes of *Misospatha tamaricis* from the Punjab, India. Its galls are globose or irregular woody growths on the branches of *T. dioica.*

The last named gall midge to be mentioned as attacking Tamarisk is *Cecidomyia tamaricis* Kollar (198). Kollar found dead and shrivelled males and females in subglobular swellings on the stems of *T. articulata* Vahl. in Egypt. He did not see either the larvae or the pupae. *C. tamaricis* is a very small species and Wachtl (316) believed that it was not responsible for the gall but merely commensal in the gall which he supposed was made by a mite. This seems highly probable.

The four galls attributed to unidentified midges are as follows: (1) small galls the shape of artichokes in the inflorescences of *T. africana* Poiret found in Sicily by Stefani (285): (ii) a fusiform thick-walled stem swelling containing white gregarious larvae on *T. gallica* L. var. and (iii) another fusiform stem swelling but woody and hard and containing a single yellowish larva; both these galls were found in Tunisia on *Tamarix* species and described by Houard (171): and lastly (iv) a stem swelling, two or three times as thick as the normal stem and green, with a narrow larval cavity and a dorsal terminal emergence hole found in Persia on *T. pallasii* Desv. and described by Rübsaamen (257).

VIOLETS and PANSIES (*Viola* Tourn. ex L.)

Three gall midges are known to attack the leaves of Violets and Pansies, while a fourth infests the fruit. This last species, *Dasyneura semenivora* (Beutenmüller), occurs in North America

and has not been recorded as a pest. The larvae of *Dasyneura affinis* (Kieffer) cause the margins of the leaves in both wild and cultivated violets to curl upwards and to become thickened. It is a pest of cultivated violets in Europe. Very similar damage is done by the larvae of *Phytophaga violicola* (Coquillet) in the U.S.A., where it is a serious pest of violets grown under glass. The larvae of a second European species, *Dasyneura violae* (F. Loew), attack pansies, causing a dwarfing of the whole plant which results in a rosette of abnormally pilose leaves. This species does not appear to have been recorded as a pest. It is possible that *D. violae* (F. Loew) and *D. affinis* (Kieffer) are synonymous; the former has been recorded, with two exceptions only, from the Pansy type and the latter only from the Violet type of *Viola*. Rübsaamen (254) suggested this synonymity, pointing out that the galls of *D. violae* on *V. tricolor* were abnormally hairy, whereas on *V. silvestris* they were not. But *D. affinis* and *D. violae* are still listed as separate species in Rübsaamen & Hedicke (263).

In addition, Houard (170) states that there are specimens of malformed flowers and buds in the "Herbarium cecidiologicum" of Hieronymus & Pax (and Diettrich) (168) which are ascribed to an unidentified gall midge.

Couderc (66) partly described another species without assigning it to a genus or naming it. He reared two females only from galls of *D. affinis* collected in October at Pamiers and in April near Toulouse.

Finally, Raymond (238) described *Cottia violarum* as a new species of gall midge attacking violets in the south of France. This is not a gall midge at all but a fungus gnat (Mycetophilidae).

Dasyneura affinis (Kieffer, 1886), the (European) Violet Leaf Midge.*

Diagnostic Character. Upward curled and thickened leaf margins of Violets (*Viola* spp.) (Plate 9).

Damage. When the outer leaves are attacked the nature of the upward leaf margin curl is more obvious than when the

* Also the Violet Leaf-rolling Gall Midge (94).

central leaves are attacked. In the latter the leaf tissue is greatly thickened and enlarged. Often a bluish coloration and a lack of hairs are apparent, while the entire leaf is malformed and distorted. When the infestation is light the leaves grow away from the attack and not much harm results, except unsightliness. On the other hand, when it is severe all the central leaves are seriously malformed and never recover sufficiently for any part to function normally. As a consequence, the whole plant is dwarfed, the flower production is nil or very much reduced, and sometimes even death of the plant results. Usually the galled leaves appear devoid of hairs, but on certain varieties of violets they exhibit pilosity. The flowers are also sometimes attacked, in which case the sepals and petals are swollen and rolled upwards.

Serious damage has been reported to cultivated violets in England, e.g. in the spring of 1946 in gardens in Bedfordshire and Hertfordshire, on the Côte d'Azur (234) and in the neighbourhood of Toulouse in the south of France (66, 234) and near Naples (54).

Description. Kieffer (183) originally described the female, larvae and gall of this species. Much later Colizza (54) gave detailed descriptions of both sexes, the egg and full grown larva. Couderc (66) made a well illustrated and detailed morphological and anatomical study of all stages. His figure of a virgin female waving her ovipositor in the air is excellent, illustrating the characteristic pose and behaviour of virgin *Dasyneura* species, as well as those of allied genera, in the presence of males of their own species.

Distribution. This species is widely distributed throughout Europe, being recorded from Sweden (317), Denmark (248), Hungary (293), Italy (14, 48, 215), Roumania [No. 51 in Brandza's collection] (44), Algeria (210), Morocco (G. Fox Wilson, *in litt.* 24.11.28), Egypt (94), France (97, 211), Portugal (295) and Great Britain. In the latter country Bagnall & Harrison (10) recorded it from all the northern counties except Cheshire, Hall (157) from Surrey and Barnes (15) in Kent. The author is indebted to H. W. Miles for the information that this midge was reported by T. Jermyn (*Proc. Somerset*

Nat. Hist. Soc., **68**, 1922, 108–21) from two localities in Somerset on *V. riviniana* and *V. silvestris*. Specimens of attacks on commercially grown violets have been received by the author from Berkshire (S. G. Jary, *in litt.* 28.10.30; R. W. Kemp, *in litt.* 13.1.37), Wiltshire (H. W. Miles, *in litt.* 20.10.44), and Hertfordshire (F. R. Petherbridge, *in litt.* 15.2.46).

Life History. Colizza (54) has studied the life cycle of this midge in detail in southern Italy, so has Couderc (66) in the south of France. The author also has some data on its rate of breeding in England.

There are several generations a year. When the midge occurs on cultivated violets in frames or under glass there is more opportunity for a rapid and continuous sequence of generations than out in the open on wild violets, especially in countries like England. But even in warmer countries like the south of France and southern Italy where violets are cultivated largely out-of-doors there is some slowing down of the rate of breeding during the winter months.

Cultivated violet plants infested by this midge were received at Rothamsted Experimental Station in the middle of January, 1937, from a grower in Berkshire. Cocoons were then present in the galls. The plants were potted and kept in the outdoor unheated insectary. Midges emerged during the first half of May. Experiments were then set up, using cultivated violet plants in the insectary and wild violet plants in a cold glass-house to discover how many generations occurred during a year. The first generation was completed when the second flight of midges were on the wing between July 5 and 29. The third flight occurred in the latter half of August and the first half of September and the fourth flight (or completion of the third generation) took place in late October and the first half of November. The fourth generation was completed when the midges finally emerged throughout May in 1938. Considerable overlapping occurred in those experiments in which the midges were allowed to re-infest the old plants and in some cases the plants became so heavily infested that, after very serious dwarfing had occurred, the plants died. In the insectary it was noticed that the fourth flight was comparatively small and

some of the third generation carried over to 1938. On the other hand, in the cold glasshouse the November flight (fourth) was much larger and few if any of the third generation were left to emerge in 1938.

Near Toulouse, Couderc found that there were five generations in the year. The first midges appeared towards the end of January and in the first half of February. The first generation was completed when the second flight of midges were on the wing during March. The third flight occurred at the end of May until mid-June, the fourth during the second half of July and first fortnight in August and the fifth (or completion of the fourth generation) in late September until the end of October. The fifth generation was completed the following January–February. Thus of the five generations in the year, two occur in the winter, one in the spring, one in the summer and one in the autumn. Couderc reported considerable overlapping of the generations near Toulouse and so much in those studied in the Alpes-Maritimes that they were not distinguishable.

At Portici near Naples, Colizza similarly reported five generations during the year. The flights of the midges being in early April, May, late June, July and September. The duration of the generations being 41, 39, 27, 62 and 206 days respectively.

In Egypt infested leaves have been found (94) every month of the year except August and December, the attack starting in July and August, reaching its height in October and drawing to an end late in November (164).

The sex ratio of the different generations apparently varies. The author found that of the first generation of the year was 43 : 57 (males : females); that of the second 37 : 63; that of the third 43 : 57; and that of the fourth (overwintering) 30 : 70. Couderc gave the following figures: 60 : 40 for the second generation (May–June); 15–20 : 85–80 for the fourth generation (September–October); and 40–45 : 60–55 for the fifth (overwintering). But the data available is not sufficient to draw any generalization.

The males only live a few hours after mating which takes place soon after emergence. On the other hand, the females live longer, particularly if they are unable to mate. On such

occasions they may survive a week. Colizza found that oviposition lasted 2–5 days and that the crest was between noon and 3 p.m. Couderc could not induce female midges to oviposit unless they had mated. Incidentally, he found no signs of the larvae reproducing paedogenetically.

As a rule the female midges oviposit on the youngest leaves, inserting the eggs within the rolled-up leaf margins, and sometimes on the unopened flowers. Colizza found galls on the flower buds as well as on the leaves, but Couderc only observed oviposition in the curled margins of the outer leaves and in the leaves of the central rosette. As a result of infestation the leaves never uncurl and in fact become more tightly curled and swollen. The galls are recognizable as such about 8–11 days after the eggs have been laid.

The larvae hatch in 4 or 5 days. At first white, they become pale orange as they approach maturity. They are gregarious and up to 24 have been reported in a single gall. In a bad infestation far more than this are likely to be found. There are about four larval moults according to Couderc, who stated that the usual duration of the larval stage was 6 weeks except in the overwintering generation.

When full grown the larvae spin cocoons within the galls, although mature larvae if placed on sand will spin their cocoons and develop normally. Pupation takes place in the cocoons and lasts about 10 days. Colizza recorded that the length of the larval and pupal periods varied from a minimum of 27 days in the spring and summer to a maximum of about 7 months for the overwintering generation.

FOOD PLANTS. Cultivated and wild Violets, including *V. alba* Besser, *V. canina* L., *V. hirta* L., *V. lutea* Smith, *V. odorata* L., *V. riviniana* Rchb. and *V. silvestris* Lamk. (for authorities see Houard (170)). Rübsaamen & Hedicke (263) give *V. silvatica* Fries (= *silvestris* Lamk.) as the food plant of this midge (see p. 115).

NATURAL ENEMIES. Colizza (54) recorded a Proctotrupid, *Platygaster* sp., and three Chalcids, *Tetrastichus* sp., *Torymus* sp. (possibly a variety of *T. abbreviatus* Boh.) and *Eutelus mediterraneus* Mayr. He figured the adults of these four parasites.

They all hibernate in the pupal stage, the *Platygaster* in the midge's cocoon and the others in the gall. The *Platygaster* is an endoparasite and the *Tetrastichus* an ectoparasite of the larvae. *E. mediterraneus* and the *Torymus* are also both ectoparasites, the latter of mature larvae and pupae. Its eggs are laid in the galls. Colizza stated that the *Torymus* alone checked the midge in the summer of 1927.

Couderc (66) found a Proctotrupid parasitizing the midge at Toulouse and a Pteromalid in the Alpes-Maritimes. The author has not yet reared any parasites in England.

Couderc also found Nematodes in the galls, but these were probably a natural sequence of the galls rotting and cannot be properly considered as natural enemies of healthy midge larvae. He also found the red spider or mite, *Tetranychus bimaculatus*, in the galls, but here again the mite is a plant pest and did not attack the midge larvae.

The author (18) described *Lestodiplosis affinis* Barnes, which he reared from larvae found eating the larvae of *D. affinis* in Kent in 1925. The type and paratype females are in his collection.

Control Measures. The old method of picking off and destroying all the infested leaves can be used. Colizza (54) suggested that this should be done every 15–20 days in the summer and autumn. But Couderc (66) pointed out that this method is only applicable in those districts where the flowers alone are used but is useless where the leaves are distilled.

Colizza stated that a cheaper method would be to transplant the violets to fresh ground, having removed all the leaves except the central buds, and suggested the second half of August as being the best season for this.

Couderc noticed that fewer galls appeared on plants exposed to the direct rays of the sun than on others grown in the shade. This may be due to the faster development of the leaves in bright sunlight and the resultant exposure of the eggs and young larvae to the direct rays (cf. Vol. I, p. 65). He therefore suggested it would be an interesting experiment to grow the violets in bright light and well separated; but he pointed out the difficulty of maintaining the correct humidity among

Picard (234) suggested the use of freshly slaked lime and Vayssière (313) suggested cultivating the soil, dusting the plants with slaked lime and other powdery substances like pyrethrum, and the use of hydrocyanic acid gas. But Couderc pointed out that none of the chemicals suggested and tried had proved effective owing to the pest being protected by its gall throughout all its life except that of the midge stage. Cultivating the soil also would not be effective owing to the fact that the larvae usually pupate in the galls.

G. Fox Wilson (*in litt.* 6.7.45) stresses the importance of applying nicotine dust at high temperatures in order to kill the larvae of such marginal leaf-rollers as this midge.

El-Zoheiry (94) stated that experiments carried out by N. Mohamed and M. Zaki showed that spraying the violet plants early in the spring with any one of the following insecticides kept the plant free from attack the whole year, although unsprayed plants in the same bed were 50 per cent. infested. It seems an extravagant claim. The insecticides were: (1) lime-sulphur (sulphur 2 kg., quicklime 1 kg. and water 100 litres), (2) Volck May (summer oil), 1 per cent., (3) Volk May and nicotine sulphate 0·1 per cent., and (4) nicotine sulphate 0·2 per cent. and soap 0·5 per cent.

Lastly, D.D.T. may prove to be very effective against this midge (see p. 41).

Biological Control. Colizza (54) suggested keeping midge-infested leaves in receptacles with glass tubes projecting into which the midges and parasites would move on emergence. The parasites could be kept alive until all the midges had died by placing honey in the tubes. Then the former could be released. Couderc also suggested biological control by means of its parasites.

Closely Allied Species. *Dasyneura violae* (F. Loew) and possibly *Phytophaga violicola* (Coquillet).

Material. Males, England (Berkshire, Kent), Germany (Weimar). Females, England (Berkshire, Kent), France (Côte d'Or), Germany (Weimar), Morocco (Tangiers). Larvae, England (Berkshire).

MOST IMPORTANT REFERENCES

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COLIZZA, C. 1928. *Boll. Lab. Zool. Portici*, **21**, 130–48 (*Dasyneura*)
COUDERC, J. 1933. *Bull. Soc. Hist. nat. Toulouse*, **65**, 193–279.

Dasyneura semenivora (Beutenmüller, 1907), the Violet Seed Midge.*

DIAGNOSTIC CHARACTER. Fruit of Violets (*Viola* spp.) distorted and swollen.

DAMAGE. The seed capsules assume a globular or irregular rounded shape, varying in size from that of a pea to a small gooseberry. In the hollow inside are to be found several larvae which are stated to feed on the deformed seed. Apparently there are no records of its damage in economic literature.

DESCRIPTION. Beutenmüller (37) first described and figured the larva and gall and later (39) gave a brief description covering both sexes. Felt (111) re-described both sexes. It is apparently a typical *Dasyneura* of rather small size, the male being 1·25 mm. long and the female 2 mm. The larva is orange in colour.

DISTRIBUTION. U.S.A. (New Jersey, Massachusetts and New York State) and Canada (Ottawa).

LIFE HISTORY. According to W. De W. Miller, who found the galls originally described by Beutenmüller, the galls occur from July until late in October. The full-grown larvae spin cocoons inside the swollen fruit and pass the winter in this state. The midges emerged between the last day in May and June 15.

FOOD PLANTS. *Viola affinis*, *V. cucullata* (= *V. papilionacea* Pursh.), *V. dicksonii*, *V. palmata* L. and *V. septentrionalis* Greene.

CONTROL MEASURES. No control has been suggested.

MOST IMPORTANT REFERENCES

BEUTENMÜLLER, W. 1907. *Bull. Amer. Mus. nat. Hist.*, **23**, 390–1 (*Cecidomyia*)
BEUTENMÜLLER, W. 1913. *Canad. Ent.*, **45**, 414 (*Dasyneura*).

Dasyneura violae (F. Loew, 1880).

DIAGNOSTIC CHARACTER. Dwarfing of the whole plant of Pansies (*Viola* spp.), resulting in the formation of a rosette of which the leaves are abnormally pilose.

* Also called the Violet Fruit Midge (121).

DAMAGE. As a consequence of attack by the larvae of this midge the internodes of the stems are greatly reduced and the leaves are thus drawn together. Their margins are curled upwards and inwards into thickened rolls. Sometimes the flower buds are also attacked in a similar manner, the petals being thickened, curled and the stamens aborted (203). Houard (in Vol. 1 of 170) described the galls as a compact bouquet of leaves with abnormal pilosity at the extremities of the stalks and later (in Vol. 3 of 170) as a tuft of leaves and flowers, which are rolled upwards and covered with short hairs.

DESCRIPTION. F. Loew (203) described both sexes, the larva and the gall of this species. The larvae are pale orange-yellow.

DISTRIBUTION. This species has been recorded from Sweden (317), Denmark (248), France (211), Saxony (268), the Tirol and Vorarlberg (69) and Great Britain. In the last-named country Bagnall & Harrison (10) recorded it from Durham and Cumberland. The record of the Deshusses (79) concerning the occurrence of this species on Violets in Switzerland probably refers to *D. affinis.*

LIFE HISTORY. Little has been published. The larvae are gregarious and are to be found at the base of the short sessile leaves in July, August and September according to F. Loew. Pupation occurs in white cocoons in the galls on the plant. The midges emerge the following June.

FOOD PLANTS. *Viola tricolor* L. (203), *V. arvensis* Murray (69), *V. tricolor* var. *arvensis* (70), *V. polychroma* Kerner (268), *V. canina* L. (84) and *V. tricolor* L. var. *hortensis* DC. (84). Rübsaamen & Hedicke (263) give *V. canina* and *V. tricolor* as the food plants of this midge (see p. 115).

NATURAL ENEMIES. None has been recorded.

CONTROL MEASURES. This midge has not been reported as a pest and no control has been suggested.

CLOSELY ALLIED SPECIES. *D. affinis* (F. Loew) and possibly *Phytophaga violicola* (Coquillet).

MOST IMPORTANT REFERENCE

LOEW, F. 1880. *Verh. zool.-bot. Ges. Wien*, **30**, 34–5 (*Cecidomyia*).

Phytophaga violicola (Coquillet, 1900), the Violet Gall Midge.*

DIAGNOSTIC CHARACTER. Curled leaves of cultivated Violets (*Viola* spp.) in U.S.A.

DAMAGE. The margins of the leaves are curled upwards and distorted. A good illustration of damaged leaves is given by Chittenden (52). Rot is liable to set in. The result of an infestation is that the plants are dwarfed and the crop of flowers seriously reduced. Felt (98, 100) stated that near Rhinebach, N.Y., violet growers estimated that their crops were reduced by one-third to one-half by this midge. Garman (146) gave an instance of one firm in Connecticut losing 1,000 dollars a year. All the records of serious damage refer to violets grown under glass.

DESCRIPTION. Coquillet (57) originally described and figured this species as belonging to the genus *Diplosis*. Felt (98, 100) referred to it as *Contarinia violicola*, later (103) he included it in a key to the species of *Mayetiola*. Felt (104) referred to it again in the genus *Contarinia* but later (114) gave a new description of the larva and re-described the male and female in detail as *Phytophaga violicola*. The author is not completely satisfied with the generic placing of this midge but has not had any opportunity of examining specimens.

DISTRIBUTION. U.S.A. Coquillet originally reported it being found at Washington, D.C., and in Virginia in 1896 and in 1897 in New York State. Washburn (323) reported it from Minnesota and Garman (146) studied it in Connecticut.

LIFE HISTORY. The midges are stated to emerge throughout the day. As regards oviposition one of Coquillet's correspondents (57) was the first to point out that violet leaves are tightly curled when they come up and that the larvae are to be found in these curls. Thus one could presume the eggs were laid in the leaves before they even unfolded. On the other hand, Felt (98, 100) stated that apparently the females preferred to oviposit in leaves which had just fully expanded and that this was backed by growers' observations that leaves which were open

* Also called the Violet Leaf Midge (121), the Violet Gall Fly (52). The term "Violet Leaf Midge" should not be used for this species as it will inevitably cause confusion with the (European) Violet Leaf Midge, *Dasyneura affinis* (Kieffer).

one day were frequently badly curled the next. But Garman (146) observed that the eggs were placed in the original rolls or folds of the leaves before they opened. This is the more probable state of the leaves when oviposition takes place. The larvae hatched in the laboratory after 4–6 days and the leaves then began to be curled more tightly, resulting in the typical twisting and malformation. When the larvae were full grown they descended to the soil, where they pupated a millimetre or so below the surface according to Garman. The whole life cycle was complete in 33–7 days during October to November. It may be shorter, possibly 21 days, during the summer. Chittenden (52) did not think the larvae pupated in the soil. In some cases they may not. Felt (98, 100) found that pupation lasted about 10 days. There are probably several generations in the year as growers have observed periodicity in the appearance of the larvae in numbers, e.g. in June, July, August and later. But no detailed study of the life history has apparently appeared in print.

Food Plants. Cultivated Violets (e.g. *V. odorata* L.).

Natural Enemies. No parasites have been recorded.

Control Measures. As regards preventing serious outbreaks certain growers have maintained that raising the temperatures of the houses in order to force the violets results in an increase of midge damage. In order to check this they advise keeping the temperature as low as possible in the early autumn and maintain that there is little or no injury when the daytime temperature is not allowed to rise above 60° F. and the night temperature is kept down to 40° F. (98, 100). Felt also suggests the advisability of taking every precaution to avoid introducing the pest with newly set plants.

This midge resembles the Chrysanthemum Gall Midge in being largely a glasshouse pest, in having several generations a year and in the midges having a short pre-ovipositional period. For these reasons its control present similar difficulties. But the emergence of the midges is not restricted to the latter half of the night; the eggs are concealed and ungettable by spraying and nicotine preparations cannot be used owing to the damage its use does to the foliage of the violets. The larvae pupate in

the soil and so afford a further opportunity for chemical and cultural control.

Fumigation with HCN is the best chemical means of control but unless it is often repeated its use gives disappointing results. It was probably owing to lack of repetition that Felt (98, 100) stated that growers had found this fumigation of little use. In some cases no doubt the fumigation was done after the eggs had been laid and when the larvae were already in the leaf curls. Similarly Slingerland & Crosby (272) did not recommend fumigation. Washburn (323) reported an instance when one fumigation although killing midges called for a second application owing to the recurrence of the trouble. Garman (146), however, reported the success of systematic fumigation by a commercial firm. This consisted of fumigating every other night using $\frac{3}{4}$ to 1 oz. sodium cyanide to 1,000 cubic feet. Violets can stand rather heavy doses of HCN and the only damage suffered by the plants was a very slight burning of the margins of some of the leaves but this did not retard the growth of the plants. After about a month or 6 weeks of such regular fumigation the houses were entirely freed of the pest. Weigel & Sasscer (328) recommended nightly fumigation with $\frac{1}{8}$ to $\frac{1}{4}$ oz. of sodium cyanide per 1,000 cubic feet for 1 hour. This fumigation kills the midges but not the eggs, larvae or pupae.

Chittenden (52) suggested second-hand the use of slaked lime on and around the plants as a means of killing the larvae and pupae in the soil. But Garman (146) did not get any satisfactory results from its use in experiments. Weigel & Sasscer (328) stated that mercuric chloride should be effective against the pupae in the soil, but apparently had not tested its use.

Chittenden (52) also stated that the use of Buhach or Persian insect powder * when the midges were flying about would be useful.

Finally, there is handpicking and destruction of the galled leaves. Growers use this to support other means. Coquillet (57) originally suggested it and Slingerland & Crosby (272) recommended it. But Chittenden (52), however, stated that this procedure would injure the crowns.

* See p. 102.

Closely Allied Species. Possibly *Dasyneura affinis* (Kieffer) and *D. violae* (F. Loew) (see introductory remarks, p. 115).

MOST IMPORTANT REFERENCES

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Garman, P. 1922. *Bull. Conn. agric. Exp. Sta.*, no. **234**, 152–6 (*Phytophaga*).

VIRGINIA CREEPER (*Parthenocissus* Planchon)

The Virginia Creepers are *P. tricuspidata* Planchon and *P. quinquefolia* Planchon. But they have appeared in the literature under a variety of names. For example, some authorities consider the true Virginia Creeper to be *Vitis quinquefolia* Lamarck (*V. hederacea* Ehrhart; *Psedera quinquefolia* Greene; *Parthenocissus quinquefolia* Planchon) and the common Virginia Creeper to be *Vitis vitacea* (*P. dumetorum* Rehder; *P. vitacea* Hitchcock; *Psedera vitacea* Greene; *Cissus quinquefolia* Sims). Both these species have also been mentioned as *Ampelopsis* species.

Two species of gall midges have been described from Virginia Creeper or Woodbine in the U.S.A.

The Woodbine Vein Gall Midge, *Dasyneura parthenocissi* (Stebbins) (281), causes a tumid vein swelling on the leaves of Virginia Creeper (*P. quinquefolia*). Jarvis (178) had previously recorded what is probably this species from Guelph, Canada. Felt (108) described the gall, larva, cocoon and empty pupal case as well as both sexes of the midge. The latter emerge in the spring. The galls were common at Nassau, N.Y., in early June. Overwintering and pupation takes place in the soil. The gall is figured by Felt (111). This midge is referred to as *Cecidomyia* species by Felt (106).

Lasioptera psederae Felt was described by Felt (132) on a single dried female reared on Virginia Creeper in June, 1924, by J. A. Reeves who was then at Ohio University, Columbus. Notes on the larva and gall are included. The gall, which is on the root and corky, is about half an inch in diameter, round or long and up to an inch or more in length. The larva is reddish yellow and is described as having a peculiar structure near the

caudal end. The larvae are nearly full grown at the end of April, pupation occurs about the middle of May and the one known midge emerged in June. It is thought that the Woodbine Root Gall Midge, *Cecidomyia* species (106, 121), is the same as *L. psederae* Felt.

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